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Understanding Desertification and Land Degradation Trends

Proceedings of the UNCCD First Scientific Conference, 22–24 September 2009, during the UNCCD Ninth Conference of Parties, Buenos Aires, Argentina

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A number of session keynote presentations are expanded in more depth in a special issue of the journal Land Degradation and Development 22 (2), available electronically at:
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Acknowledgements

A unique consortium came together to organize the conference: the Dryland Science for Development (DSD) consortium. DSD was a non-profit, international consortium composed of five core partner institutions (listed alphabetically): DesertNet International (DNI), International Center for Agricultural Research in the Dry Areas (ICARDA), International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), the Joint Research Centre/Institute for Environment and Sustainability of the European Commission (JRC/IES), and United Nations University – Institute for Water, Environment and Health (UNU-INWEH).

DSD was chaired by Dr. Mahmoud Solh, Director General of ICARDA. Mark Winslow coordinated the group, which organized its work around three Working Groups. These were led by (for Working Group 1) Michael Cherlet, Stefan Sommer and Jürgen Vogt of JRC/IES; (for Working Group 2) Christopher Martius (ICARDA) and Mark Winslow (ICRISAT); and (for Working Group 3) Mariam Akhtar-Schuster, Giuseppe Enne and Chiara Zanolla (DesertNet Secretariat), and Harriet Bigas and Richard Thomas (UNU-INWEH).

Dryland Science for Development consortium is very grateful to Dr. William D Dar, Chair of the Eighth Committee on Science and Technology (CST) of the United Nations Convention to Combat Desertification (UNCCD) and Director General of ICRISAT, for his unwavering commitment and support in guiding the conference process. We are also grateful for the support of his colleagues in the CST Bureau, particularly Dr. Richard Escadafal, senior scientist, IRD, Cesbio (France).

We also thank the UNCCD Executive Secretary, Mr. Luc Gnacadja, who consistently encouraged stronger scientific input into the UNCCD. We are equally appreciative to Prof. Klaus Kellner, Chair of the Ninth CST, for co-chairing the conference and continuing to build strongly on the outcomes of the conference within the UNCCD during the subsequent two years.

We offer special thanks to Prof. Elena María Abraham, Director of the Argentine Institute for Research on Arid Lands of the National Council for Scientific and Technical Research (IADIZA-CONICET) and a globally recognized leader in dryland degradation science, who organized the large poster session at the conference. The session was a great success, as evidenced by the number and quality of abstracts included in this Proceedings.

DSD partner institutions also provided substantial time and financial resources to organize the conference. We are thankful to each institution for committing these resources to advancing the progress of the UNCCD. We also thank the institutions that hosted the Working Group meetings, including DSD core partner institutions, the UNCCD Secretariat, and the Center for Development Research (ZEF), Germany, led by Executive Director Prof. Paul LG Vlek.

The scientific quality of the conference was a product of 18 months of preparatory deliberations organized by DSD. The three Working Groups were instrumental to this process. DSD invited leading land degradation experts to participate, convened electronic discussions and group writing, and organized seven Working Group meetings with participants coming from across the globe. More than 100 leading scientists took part voluntarily in the Working Group processes; we are very grateful for the high caliber of expertise and considerable time that they contributed.

For organizing the conference in Buenos Aires, we extend our deep gratitude to our hosts in Argentina, who ensured that it was a fruitful and enjoyable experience for all involved. Particular thanks go out to Ing. Octavio Pérez Pardo and Lic. Vanina Pietragalla, both of the Directorate for Soil Conservation and Combating Desertification within the Secretariat of Environment and Sustainable Development, for making the hosting arrangements. The UNCCD Secretariat worked closely with partners in Argentina to arrange the conference logistics. We particularly thank Elysabeth David, Håkan Marstorp, Lawrencia Eposi, Yukie Hori and Lindsay Stringer for their vital contributions.

We are further indebted to Alfred de Jager (JRC/IES) for establishing and maintaining the DSD website, Jan Möller (DesertNet Secretariat, Hamburg) for administrative support, and R Narsing Rao (ICRISAT) for managing the complex logistics of meetings, travel and expenses.

None of this would have been possible without financial support from donors. They stepped in quickly, despite the tight time frame, to ensure that crucial meetings were funded and in particular to ensure that developing-country scientists could participate. In addition to the support provided by the five consortium institutions, we are extremely grateful to the European Commission (EC), the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), acting on behalf of the German Federal Ministry for Economic Cooperation and Development (BMZ), the International Fund for Agricultural Development (IFAD), and the United Nations Environment Programme (UNEP) through the Global Environment Facility (GEF), for these contributions and their active interest in strengthening the UNCCD. We are also grateful to the UNCCD Secretariat for assisting in raising funds.

Dryland Science for Development consortium

DSD = { DesertNet International; ICARDA; ICRISAT; EUROPEAN COMMISSION JRC ies Institute for Environment and Sustainability; UNITED NATIONS UNIVERSITY UNU-INWEH }

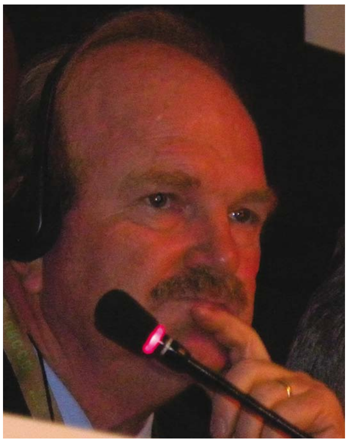
Proceedings

Opening session

Opening remarks by the CST Chair

***Klaus Kellner**, Chair, UNCCD Ninth Committee on Science and Technology (CST-9)*

Credit: C. Martius



Klaus Kellner

It is my honor as CST Chair to formally launch this innovative agenda item, the First UNCCD Scientific Conference on 'Understanding Desertification and Land Degradation Trends'. Let me welcome you all here and thank you sincerely for coming. My special thanks to our host country Argentina for the tremendous effort they have made in providing this beautiful venue and making all the arrangements. I also want to thank the UNCCD Secretariat for its hard work and dedication in facilitating this new conference format.

To my scientific colleagues who may be new to the UNCCD process: a special thanks. I know this was a long trip for most of you and takes you away from many pressing duties. Many of you have made a special effort to create posters describing your work. Others have contributed to the Working Groups and White Papers. Thank you very much for enriching this conference.

You may not be fully familiar yet with the UNCCD and how our effort contributes. The complexity of United Nations (UN) processes may leave you feeling a little bit bewildered at times. Let me assure you that the cause is well worth the effort. This important body has a strong influence on national decision-making to combat land degradation, helping our science to make a difference in the world.

The UNCCD is unique as the only global policy body focused on combating desertification, land degradation and drought, which I will call "DLDD" from now on. The UNCCD recognizes the need to improve the scientific basis supporting its work. It has given us the responsibility of re-invigorating that scientific process.

A successful conference will go a long way towards the renewal of the UNCCD, as called for in the UNCCD's 10-Year Strategy.

In the Conference of Parties' (COP) own words, they expect us to deliberate on "biophysical and socio-economic monitoring and assessment of desertification and land degradation, to support decision-making in land and water management".

The UNCCD realizes that it needs cutting edge science to monitor and assess DLDD. It needs this so that the national Parties to the Convention to Combat Desertification can measure DLDD more accurately and track progress in solving it. This needs to be done in ways that can also be compiled into a global picture for our international supporters.

The UNCCD looks to us, the conference participants for guidance on how to do this. Past difficulties in describing DLDD have led to controversies that have slowed the UNCCD's progress. If we can help the UNCCD become more precise and clear about what DLDD is, where it occurs, what causes it, and how effective the solutions are, then the UNCCD will gain more credibility in the eyes of the world. That credibility will increase support for combating DLDD, a goal that we as scientists all share.

We are pioneering a new model in this scientific conference and will learn a lot from this event. It is a transformation in the way that the Committee on Science and Technology does its work. In the past, the Committee followed formal UN protocols rather than scientific protocols in its discussions.

Our task here is to strengthen this. We must engage in a scientific conference that transcends fixed mindsets based on political considerations. We must discuss scientific issues in an open and objective way, on the basis of research and scientific evidence. Likewise, we must consider other views and be open to being challenged.

Organizing a conference like this is a major task. Hence, our Committee on Science and Technology wanted this to be carried out separately from the UNCCD political process to highlight the science.

We then called for an appropriate partner to assist us in organizing the conference, and chose the Dryland Science for Development consortium, or DSD. I want to offer a special note of thanks to DSD for the huge amount of work they put into this, and also thank the donors that supported them in this process: the EC, GIZ/BMZ, GEF/UNEP, IFAD and the UNCCD Secretariat and the Global Mechanism.

The DSD's five member institutions contributed substantially to make this conference a reality. The whole UNCCD community owes them a big debt of gratitude.

Together with DSD, the CST Bureau decided that a special conference format was needed in order to lead to clear scientific messages and recommendations in a short period of time. The DSD organized three Working Groups to deliberate and prepare draft messages and recommendations in order to stimulate and orient our discussions.

Right after the last session, DSD will meet to finalize the messages and recommendations, taking your inputs into account. I think you can appreciate that this will be a difficult task, since DSD will need to integrate the rich and diverse input coming from all of you. Nevertheless, we expect DSD to come up with a final synthesis that will faithfully reflect our prevailing scientific views.

Our role in the Committee on Science and Technology will be to review carefully the conference messages and recommendations on Friday morning and communicate our views to the full Conference of Parties for action and follow-up. Your messages will remain intact as part of the record of this Conference of Parties.

Finally, I have one special request to make of you. We need to free our minds beyond institutions, processes and procedures, and create a broad space for open and solid scientific discussions. Let us therefore take full advantage of this opportunity by focusing our discussions on science and technology issues. In this way we will add a new dimension of value to the whole UNCCD process.

By 2050, the world will have to feed two to three billion more people and cope with higher demands for water. With climate change, the World Bank also estimates that we need to increase global farm productivity by at least 1.8% every year. For the world to survive this crisis, we need to work together in the name of science and transcend economic and political considerations. This is the challenge of this conference.

As I close, I sincerely hope that you will find this event stimulating and fruitful. We depend on you to bring forward the best ideas that modern science has to offer. Together, we can make this event a great success and make our world a better place for present and future generations.

Thank you and have a good day.

Opening remarks by the Chair of the UNCCD First Scientific Conference

***William D Dar**, Chair, UNCCD Eighth Committee on Science and Technology (CST-8)*

Credit: C. Martius

William D Dar

Dear friends,

It is an honor to chair the UNCCD First Scientific Conference under the Ninth Session of CST.

This is a pioneering scientific conference of the UNCCD, one that pledges to make room for substantive scientific discussions on combating desertification, land degradation and drought. It has engaged the scientific community to an extent and intensity unmatched in the history of the Convention. Its organization required nearly two years of continuous effort, involving many people and institutions worldwide.

The process began with the Convention's recognition of the need to improve the flow of scientific knowledge into its processes. The conference was triggered when the UNCCD Eighth Conference of Parties in Madrid in 2007 decided "that each future ordinary session of the CST shall be organized in a predominantly scientific and technical conference-style format by the CST Bureau in consultation with the lead institution/consortium" (Decision 13/COP.8).

Following this decision, the Eighth Committee on Science and Technology called for expressions of interest by consortia to organize the conference. The DSD consortium was chosen and launched an intensive process, under CST's guidance, to bring the conference to fruition.

Our journey from CST-8 in Madrid to CST-9 here, in this beautiful city of Buenos Aires, has been a busy and fruitful one. We have handled many fundamental issues of reform called for by the 10-Year Strategy of the UNCCD. We were asked to reshape our processes and our program of work, and we have done so. We have launched a 'Scientific Conference' format and we have adopted a very inclusive, consultative and evidence-based approach. We must continue to carry these reforms forward.

We should recall the reasons why this new path is so important. The world is facing a 'perfect storm', with a number of huge problems converging around land issues. At the center of this storm are the poor, who depend on the land for survival – yet, they are unable to fight off the massive storm clouds that are building.

Already beset by poverty and hunger, the World Bank estimates that developing countries will bear 80% of the environmental costs to mitigate climate change. Climate change threatens harsher temperatures, droughts and storms, all of which can send the poor right back to the bottom of the development ladder. Increasing population pressure and poverty will increase the intensity of this perfect storm, and the suffering that it causes.

Our whole UNCCD community recognizes that we need science to better understand this storm and to devise solutions that work for the poor. We need options for people that reduce their vulnerability and increase their resilience. We need options for the land that prevent irreversible losses of precious natural resources like soil, biodiversity and water. We need both policy and technical options – the two go hand in hand. Again, the key message is this: people and land matter.

Let us have your positive engagement for a rich scientific discussion in our First Scientific Conference. Many eyes are watching us to see if we are brave enough to walk down this new path. If we hesitate or turn back, they may walk away from us. But if we are bold and continue forward, we will find many new friends along the way. And together we will find ways to weather the perfect storm.

Thank you.

Statement by the UNCCD Executive Secretary

Luc Gnacadja, Executive Secretary UNCCD

Credit: C. Martius

Luc Gnacadja

Dear friends, ladies and gentlemen,

It is a pleasure to welcome you all to the UNCCD 1st Scientific Conference. I thank the Argentinean government for providing the opportunity to make this Conference happen. I congratulate the Drylands Science for Development (DSD) consortium and the three Working Groups for their untiring work and dedication to make this UNCCD 1st Scientific Conference a success. Special thanks are also due to the Committee on Science and Technology (CST–8) Bureau for its continuous commitment to the process.

I am sure many of you are aware that the UNCCD is the Rio Convention with the largest number of ratifications – 193 – and is unique, being the only international convention at the interface of environment and development. Despite this, it receives relatively limited global attention compared to its sister Conventions on Climate Change and on Biological Diversity, and in spite of the global nature of the desertification, land degradation and drought (DLDD) challenge.

According to the 2005 assessment of the UN Joint Inspection Unit, the absence of a dedicated science program and consequent lack of scientific input into UNCCD processes is one of the main reasons for this limited attention. A number of scientific papers have reached this conclusion too. They argue that we have not convincingly explained in simple terms what desertification, land degradation and drought are, or how these challenges should be measured, monitored and assessed.

To take the Convention forward and implement the 10-Year Strategic Plan and Framework for the Implementation of the Convention (2008–2018), we need to know where DLDD is happening, how severe it is, how much harm it does to affected people and ecosystems, and the economic costs that it incurs. We need to show the world why land matters and encourage them to sit up and listen. Only with this knowledge can we develop appropriate interventions and attract the required investment of resources.

Therefore, we need knowledge on the biophysical and socio-economic factors, and their interactions, in affected areas. We need knowledge on the interactions between climate change adaptation, drought mitigation and restoration of degraded land, and we need knowledge-sharing systems that include traditional and indigenous knowledge to help us better understand the impacts of, and solutions to, DLDD.

Numerous pioneering efforts are currently underway in various parts of the world. They include the LADA program right here in Argentina. Although the amount of scientific knowledge and data is growing, it remains fragmented and is not easily accessible to decision makers. There is also a lack of common standards and methodologies for monitoring and assessing.

Our critics acknowledge that addressing these challenges is not easy. We were bold and ambitious when we created the Convention, linking the land to people, to policies and to livelihoods, embracing new and almost radical concepts of human-environment system linkages. This also requires new types of science and knowledge management in order to take a more integrated approach towards combating DLDD. Despite this need, the breadth and depth of the available scientific information is yet to be mobilized and harnessed to its full potential.

We were convinced then, at the birth of the Convention, and remain convinced now, that DLDD is widespread, serious and in need of urgent action. But we have not been able to represent its complexity in simple, clear terms that can be accounted for by governments and investors. Understandably, this makes them uneasy. They too need to account for their investments in clear and concrete terms.

This UNCCD 1st Scientific Conference marks a new beginning for the Convention. The Scientific Conference stems from the 10-Year Strategic Plan and Framework for the Implementation of the Convention (2008–2018), which recognizes that we need the help of scientists to better define and measure the problems of DLDD and to inform us about the progress being made to combat the problem.

I am therefore delighted that COP 8 took the bold decision to create a two-and-a-half day space here at COP 9 that is solely dedicated to scientific discussion on the topic of biophysical and socio-economic monitoring and assessment of desertification and land degradation to support decision-making in land and water management.

I appreciate that the scientific community has not been given an easy task. Technology transfer, capacity building and financial cooperation are all needed in order to support stronger scientific input into the UNCCD.

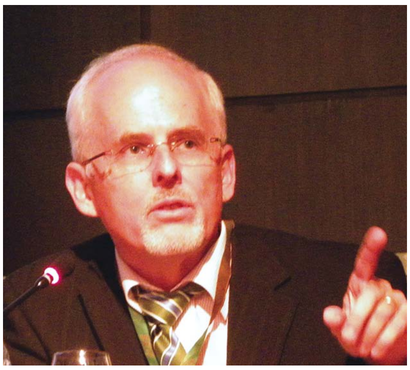
But, DLDD is a complex problem, and we have to face this challenge in all its complexity. We cannot artificially simplify it to make our jobs easier. Therefore, it is vital that scientists and all stakeholders embrace this challenge and its complexity in its entirety and work together to move the UNCCD forward.

We cannot afford to run away or defer the problem to future generations.

Working Group process leading to the UNCCD First Scientific Conference 'Understanding desertification and land degradation trends'

Mark Winslow, DSD Coordinator / ICRISAT, Hyderabad, India

Credit: C. Martius



Mark Winslow

Overview

The conference, which took place from 22 to 24 September 2009 in Buenos Aires, Argentina, was the culmination of an 18-month process involving over 100 scientists worldwide who participated in three Working Groups, with crucial donor support. We are very grateful to all who contributed (see Acknowledgements).

Topic and Working Groups

The theme of the conference assigned by the UNCCD Eighth Conference of Parties was 'Bio-physical and socio-economic monitoring and assessment of desertification and land degradation, to support decision-making in land and water management'. This theme was distilled into the popular title 'Understanding Desertification and Land Degradation Trends'.

DSD decided to enrich the analysis by examining it from three complementary vantage points, each assigned to a Working Group:

- Working Group 1: monitoring and assessment of land degradation per se
- Working Group 2: monitoring and assessment of prevention/recovery from that degradation through sustainable land management
- Working Group 3: monitoring and assessment of knowledge, social, economic, policy and institutional dimensions of land degradation that have received insufficient attention in the past.

Outputs

The Working Groups' preliminary findings were twice shared over the Internet for public comments, in late May and early August 2009. The third round of discussion occurred at the First Scientific Conference itself.

Based on these deliberations, DSD submitted a set of 11 recommendations to the Ninth Conference of Parties, which is available from the UNCCD (identified by the document number ICCD/COP (9)/CST/INF.3). The final White Papers are available at the DSD website (http://dsd-consortium.jrc.ec.europa.eu).

The main conclusions of the Working Group deliberations were published in a more concise form in a special issue of the peer-reviewed scientific journal *Land Degradation and Development*, 22(2), 2011.[1]

The third major element of documentation is these conference proceedings. Additional public awareness documents were produced through collaboration between DSD and the UNCCD Secretariat.

In addition to the White Papers, DSD placed an open call on the Internet for poster presentations relevant to the conference topic. More than 40 posters were approved and displayed. Summaries of these posters are included in these proceedings.

We hope that these deliberations and publications, as well as the conference itself, are useful in strengthening the role of science in the deliberations of the UNCCD.

Keynote presentation 1
Desertification assessment and monitoring in Argentina

***Elena María Abraham**, Argentine Institute for Research on Arid Lands (IADIZA -CONICET)*

Abstract

An overview of the current status of desertification monitoring and assessment in Argentina is presented. This explains the severity of the problem that affects 70% of the national territory and discusses the background of scientific national organizations engaged in the National Action Plan. A state-of-the-art review of predominant approaches and results of permanent sites for desertification monitoring and assessment in different regions are explained. An analysis is made of the current national and international science and technology sector, its evaluation and promotion procedures, its performance in desertification studies and of the role that science and technology have played in the UNCCD.

Credit: C. Martius

Elena María Abraham

Drylands and desertification in Argentina

The popular image of Argentina is that of "Pampa Húmeda" (the humid Pampa). This image is distorted. The reality is that three-quarters of the country are dryland and face desertification.

Argentina occupies an area of over 270 million hectares (ha). Arid and semi-arid regions comprise 70% of the national territory. The arid region is the largest one (52%). This reality ranks Argentina as the ninth country in the world in terms of percentage of drylands and as one of the 14 countries where these lands occupy over

[1] http://onlinelibrary.wiley.com/doi/10.1002/ldr.v22.2/issuetoc

1 million km^2. At present, 60 million ha show moderate to severe erosion. This region is inhabited by about 10 million people (30% of Argentina's total population).

Drylands in Argentina include several regions with different ecological and land uses, which also differ in the combination of the desertification processes affecting them: recurrent droughts, wind and water erosion, overgrazing and diminishing plant cover, deforestation, loss of soil fertility, salinization and water logging and biodiversity loss. All regions share problems of poverty, emigration, unstable land tenure, deficiencies in productivity and marketing and little diversity in agricultural production. The consequences of these processes are productivity loss and deteriorating living conditions; average incomes are lower and structural poverty higher than at the national level.

In Argentina, with 83% of the population living in urban areas, a major problem is the anarchic expansion of cities over fragile lands. The desertification of urban outskirts results from the social pressure exerted by migrant people from rural areas.

Arid regions have only 12% of the total national surface water resources that, along with available groundwater, have allowed important productive activities to develop in the 1.5 million ha covered by the oases. Over the last 75 years, natural forests have been depleted by 66%. Timberwood, firewood and charcoal, overgrazing, and clearing for crops and livestock breeding all cause large-scale tree felling. Deforestation is estimated at 850,000 ha/year – a rate that will lead to the total loss of this valuable resource by 2036. As for biodiversity, 40% of the animal and plant species of marginal regions are endangered (SAyDS 1997).

Experiences and institutional capacity in the scientific and technological sector

In Argentina activities to combat desertification began before the implementation of the UNCCD. Scientists were among the first to seriously consider desertification in drylands. The development of science and technology institutions for dryland management gave the country initial advantages in institutional capacity and qualified human resources, which facilitated the establishment of the National Action Plan to combat desertification. Major institutions addressing desertification include:

- the National Institute of Agrarian Technology (INTA), created in 1956
- Institutes of Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET, National Scientific and Technical Research Council) such as IADIZA, created in 1972 in Mendoza
- the Centre for Renewable Natural Resources of the Semiarid Zone (CERZOS), created in 1980
- the National Patagonian Centre (CENPAT), established in 1970.

In addition, a number of universities focused on knowledge of drylands, among them the University of Buenos Aires (UBA) with the Institute for Physiological and Ecological Research linked to Agriculture (IFEVA).

Argentina is one of the countries that has progressed the most in relation to the recommendations of the UNCCD's CST, since work on developing indicators at local and regional level had already begun before implementation of the Convention. By 1988, results on this thematic issue had already been generated (see Abraham and Prieto 1988; Roig 1989; Roig et al. 1991; Del Valle et al. 1998).

Once the National Action Plan was developed, activities continued. Between 1997 and 2001, representatives of the major scientific institutions formed the Argentinean Group for Desertification Indicators, identifying biophysical and socio-economic indicators in the framework of status, dynamics and response. This initiative emerged not only at the national level but also with the goal to build capacities and generate a network for managing knowledge about desertification in Latin America and the Caribbean (LAC).

This capacity building is attested by successive courses and projects conducted by IADIZA and other institutions. These include:

- Latin American courses (1987, 1989 and 1993) financed by UNEP and the Food and Agriculture Organization of the United Nations (FAO)

- projects on Benchmarks and Indicators by the Economic Commission for Latin America and the Caribbean (ECLAC) and GIZ (2002)
- participation in programs of the European Union like the 'northern Mediterranean regional action programme to combat desertification' (MEDRAP) and the 'Active exchange on indicators and development of perspectives in the context of the UNCCD' (AIDCCD) that enabled a fluent exchange of experts from Europe and LAC
- the Argentine–German cooperation through GIZ to train different agencies in developing indicators; and decision support systems developed by GIZ and INTA.

The UNCCD Thematic Programme Network 1 (TPN1) on Benchmarks and Indicators was established in LAC in 2003, coordinated by Argentina. An important contribution was made by the Program to Combat Desertification in South America (Argentina, Bolivia, Brazil, Chile, Peru and Ecuador, 2002–2005). National workshops were carried out through this project to obtain Benchmarks and Indicators at national levels and case studies at the local level (Abraham and Beekman 2006).

Regional experiences

The implementation of Land Degradation Assessment in Drylands (LADA) Argentina deserves special mention. It began in 2003, coordinated by the National Focal Point and involving numerous national institutions in an articulated initiative. It is currently validating a standardized methodology for assessing land degradation at the national level (through the National Monitoring Group) and at five pilot sites: Puna, Cuenca Río Miraflores; Arid Valleys, Santa María; Monte Desert, Lavalle; and two sites in Patagonia, Ing. Jacobacci and Cushamen Reserve. The aim is to measure and assess the extent and nature of land degradation in different locations in Latin America as per the mandate of TPN1.

i) Puna: 94,818 km^2; 20°C January–10°C July; rainfall 278 mm/year

The area is a high plateau 3,500m altitude. Lake and river basins alternate, surrounded by alluvial fans, glaciers and mountain ranges from 4,500 to 5,200 m altitude.

In 1948 the UBA started research on the degradation of the Argentine Puna and the arid valleys from La Rioja to Quebrada de Humahuaca. The Institute for Archaeological Research of the UBA was founded in Tilcara, with several teams from La Plata Museum. The INTA of Abra Pampa also contributed to the effort. Since 1987 the UBA, through its Center for Teledetection Research and Use has systematized the contributions to the knowledge of land degradation in the area, mostly through the LADA Argentina Project. Data on the hot site (Pumahuasi) and the bright site (Abra Pampa Oeste) point out the differences in plant cover recovery, from < 5% of shrubland and 1% of grassland in the first case to 10% and 50% respectively in the second (Navone, personal communication).

ii) Dry Chaco: 497,684 km^2; 25.9°C January–9.9°C July, temperate–semi-arid; rainfall 200–450 mm/year

This region is dominated by xerophytic shrubland with isolated trees and a discontinuous layer of low forage-quality grasses. Since colonization (about 400 years) the region underwent continuous overgrazing by cattle and goats and intense woodland logging. Traditional cattle production averaged 4 kg of meat/ha with 45% weaning rates on fields with carrying capacities lower than 20 ha/animal unit, with crises during drought seasons.

In 1968 INTA initiated studies of carrying capacities in the cattle ranch Balde El Tala, south of Llanos de La Rioja to design and assess a cattle breeding system able to make cattle production compatible with recovery and conservation of natural grasslands. After 40 years the results showed that by using natural grassland and rangeland management strategies in a semi-arid region it is possible to restore a carrying capacity by recovering natural resources, to attain cattle reproduction indices above 80% and to increase meat production by 300% (Orionte et al. 2001; Blanco et al. 2008). These investigations are complemented by quantitative measurement of degradation levels with use of remote sensing by groups of national universities, particularly La Rioja, INTA, IFEVA and CENPAT.

iii) Southern Caldenal rangelands: 301,516 km²; temperate–semi-arid, 15°C; rainfall 400 mm/year

In this grass steppe with shrubs and trees, rangeland degradation is evidenced in species replacement, soil loss, reduced forage production and reduced carrying capacity. Researchers from CERZOS have studied the structure and functioning of Southern Caldenal rangelands over the last 30 years, dealing with a number of topics related to plant ecophysiology, plant demography, nutrient cycling, fire ecology, vegetation dynamics and diet selection by domestic and wild herbivores (Fernandez et al. 2009). Science-based technology is currently being applied in a Demonstrative Cow-calf Operation System and includes conservative stocking rates, rotational grazing, controlled burning, species introduction and breeding herd control. The results show meat production significantly increased and rangeland conditions greatly improved. Thus, a regular grazing system produces only 12 kg of meat/ha whereas an improved system yields 22 kg/ha (Distel, personal communication).

iv) Monte Desert: 470,560 km²; 15°C January–19°C July, arid–semi-arid; rainfall 80–400 mm/yr

The physiognomy of an environment depends chiefly on its degradation status: dense thickets of small trees, open woodlands and savannas with isolated trees, tall and low shrublands and bare land. Researchers from IADIZA have studied the structure and functioning of the Monte desert for the last 40 years. Research projects have addressed ecology, biodiversity, vegetation dynamics, re-vegetation, sustainable range management, integrated desertification monitoring and assessment, local sustainable development and social and cultural issues.

IADIZA administers the biosphere reserve of Ñacuñán (through the MAB Program), which in practice has functioned as an observatory of knowledge of the Monte desert. As an experimental area of the reserve, the El Divisadero Cattle & Range Experimental Station (which is 520 m altitude) is used for the study of sustainable range management on native grasslands.

The results obtained in terms of improved natural grassland and meat production are indicative: before 1985, with continuous grazing the carrying capacity was 35 ha AU-1 with meat production reaching 3 kg/ha/year and the amount of plant species preferred by cattle was 1.1 m². The current situation shows a notable improvement: under rotational grazing (four paddocks, one herd) the carrying capacity increased to 25 ha AU-1, meat production to 4.7 kg/ha/year and the number of plant species preferred by cattle to 1.6 m² (Guevara et al. 2006).

Among the primary objectives is an integrated desertification assessment seeking to interpret desertification as a complex problem, highlighting the multiple relationships among the biological resources, the different land uses and their impacts (Abraham 2003; Abraham et al. 2006). A multi-scale and multi-temporal approach is incorporated into this assessment process through contributions of environmental history (Abraham and Prieto 1991). This kind of study is fundamental at the time of designing strategies for developing desertified territories. Over the last few years a strong participatory approach has been added to these scientific activities to contribute to the empowerment and sensitization of local communities.

v) Patagonia: 542,882 km²; 3°C January–12°C July, arid–semi-arid; rainfall 200 mm; ranging from 800–1000m altitude)

The environment here is dry shrub steppe subjected to intense overgrazing processes since the introduction of sheep herds by the end of the 19th century. Degradation is mostly evident from the loss of cover of perennial grasses of high forage value and by the acceleration of soil erosion.

Natural grasslands in Patagonia are the basis of a traditional cattle production industry. The primary actors in desertification monitoring and assessment in Patagonia are INTA, CENPAT and national universities such as Comahue, Patagonia Austral and IFEVA (UBA). Since 1981 CENPAT has conducted assessment and monitoring in the Chubut province grasslands on *Festuca pallescens* (in the south-west) and *Stipa tenuis-Chuquiraga avellanedae* (in the north-east). Three enclosures were built at Río Mayo for assessing the effect of sheep grazing on soil physical and chemical characteristics and in adjacent grazed areas. At Punta Ninfas three enclosures were built in 2003 to define degradation states, identify changes in the cover of perennial grasses and assess soil erosion (Rostagno and Videla, personal communication).

INTA leads efforts for long-term monitoring and assessment of large ecological areas at the regional level to assess ecosystem changes. As of 2004 a unified field-monitoring methodology was agreed and adopted for the PNUD GEF 07/35 Project. The establishment of 600 monitors in the arid and semi-arid area is already under way with enough density to assess large ecological areas in the region, approximately one per each 100,000 ha (Oliva, personal communication). The monitors are designed to assess cover type (Point quadrat method), patch structure (Canfield lines) and soil function in inter-patches. A series of derived indicators include plant diversity, invasion by species, level of shrub encroachment, stability, infiltration and nutrient recycling. Soil samples are taken to assess organic carbon and texture changes that will allow detection of erosion/deposition processes. An initial set of 40 monitors were set up in six provinces, from Tierra del Fuego to La Pampa. A unified database accessible through the internet is under development. This system initiates a long-term monitoring effort.

Conclusions

Argentina recognized early the importance of generating knowledge on drylands, the virtue of an important institutional presence *in situ* of the science-technology sector. This has generated a valuable array of experiences, knowledge and data, but particularly a critical mass of actors involved in monitoring and assessment, articulated in a national science and technology system. Argentina has designed and implemented a National Action Plan that includes knowledge generation and desertification monitoring and assessment. There is good development of experiences on desertification monitoring and assessment at the national level, particularly in areas of influence of research centers. Regions like Patagonia that have received important financing in recent years have successfully extended their experience to large parts of the territory, but this has not been true for other regions in the country. Related to this situation is the lack of continuity in the collection of basic data required for monitoring, which is either nonexistent or disrupted by economic issues.

Building a national database and collection system must become a priority. The foundations are laid but still pending are a stronger institutional articulation, a national map of affected areas and the implementation of an integrated monitoring and assessment system. Great expectations are placed on LADA, which has consolidated monitoring and assessment teams at national and local levels. Work with Benchmarks and Indicators has been greatly developed. The early association between scientific, decision-making and non-government sectors has made participatory approaches easier. Many non-governmental organizations have received and provided training and have become actors in local development projects including desertification monitoring and assessment.

It is important to perform a self-critique of the role that the science and technology sector has played in combating desertification. There are two views to this exercise: one is to look inside the UNCCD, and the other inside the science and technology sector.

The UNCCD has created a Science and Technology Committee but has not facilitated the participation of genuine representatives of the science and technology sector. This sector – the one that generates knowledge – was always indirectly present, at best through ad hoc groups or by invitation by the cooperation agencies. This has widened the gap between knowledge generation and problem solving. Scientists and technicians have felt excluded from the process and stakeholders do not receive the necessary knowledge to face the problem and claim for policies to combat desertification. Knowledge generation remains fragmented and inarticulate.

Also, the scientific sector should undertake a self-critique, because in many cases it excludes itself from decision-making processes, showing no commitment to the problems of the 'real world'. A science that is only 'for papers' but far from reality cannot contribute to problem solving. Likewise, a science where more and more partial and specialized views are prioritized cannot apprehend the complexity of desertification processes, which requires an integrated approach.

The evaluation of scientists cannot be based only on the number of papers they publish in indexed international journals. Activities on technology transfer, local development, capacity building and training of local human resources should also be counted, but this is not happening today. This sector should be trained and make a great effort, along with decision makers, to ensure the transfer of knowledge to local people in the affected areas and to generate and recover traditional knowledge and technologies.

If we manage to have a science and technology sector capable of responding to the needs of society, committed to the problems, respectful of the contributions and necessities of local populations, able to dive deeply into their special disciplines, but also building new contributions from an interdisciplinary perspective and working seriously on transfer, diffusion and capacity building then we will have succeeded in changing the map of desertification. We must invest in knowledge and sensitization.

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Keynote presentation 2

The role of science and technology in combating desertification, land degradation and drought in the dry areas

***Mahmoud Solh**, Chair, DSD consortium and Director General, ICARDA, Aleppo, Syria*

Mr. Chairman, colleagues and friends,

It is my honor and privilege to be able to participate in this first UNCCD Scientific Conference on 'Understanding Desertification and Land Degradation Trends'.

Mahmoud Solh

I would like to present a brief overview of the main issues that, in my view, require our attention, not only in improving the monitoring and assessment of desertification, land degradation and drought but also in providing the information that both policy makers and land users need in order to combat desertification, land degradation and drought. Ministers of environment and agriculture, for example do not have the data needed to convince planning and finance ministers of the high costs of doing nothing to combat desertification and control land degradation – costs that are devastating to the rural people and national economies of dryland countries.

To understand desertification and land degradation it must also be recognized that they are an integral element of a nexus of global development challenges – poverty, climate change and food security – and must be addressed within that context.

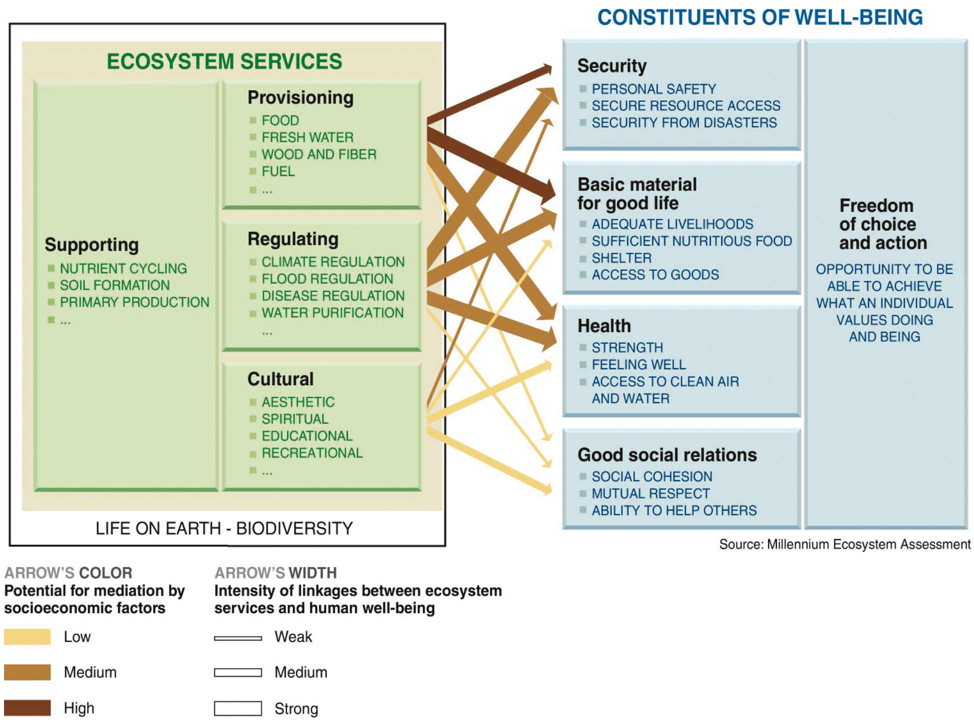
Within this context, I shall focus on the dry areas of the world, which are the most vulnerable to desertification, land degradation and drought, and particularly on agricultural land, where the effects of desertification directly affect food security, rural incomes and national economies. The fragile ecosystems of the dry areas are highly vulnerable to land degradation and desertification. Farmers in these areas already face harsh and variable weather and limited resources. We must clearly demonstrate progress in helping them deal with the limitations of today if they are to have any hope of adapting to climate change tomorrow.

Dry areas cover 41% of the Earth's surface and are home to over 1.7 billion people – and the majority of the world's poor. About 16% of the population lives in chronic poverty, particularly in marginal rainfed areas. The recent Millennium Ecosystem Assessment Report indicates that desertification threatens over 41% of the Earth's land area; 20–70% of drylands are already degraded, resulting in a decline in agricultural productivity, loss of biodiversity and the breakdown of ecosystems. Environmental goods and services such as fuelwood, medicinal and food plants, habitat for wild animals and grazing for livestock, soil fertility and soil moisture for agricultural production and therefore the productive capacity of the land users depending on those goods and services are all lost.

Desertification is not simply a force of nature; it is caused by a combination of multiple social and biophysical factors that can be grouped into two categories: those due to climatic and natural causes including variations in climate (drought), wind and water erosion, and epidemics of pests and diseases; and those due to human activities including overgrazing, deforestation, intensification of agriculture, salinization, urbanization, pollution and conflicts.

Land users are both the drivers and the victims of desertification. The process is exacerbated by poverty: land users are caught in a vicious cycle whereby increasing land degradation and loss of livelihoods drives them to place increasing pressure on fragile resources. Optimizing the interplay between ecosystem services and human well-being was the central strategy advocated by the Millennium Ecosystem Assessment (Figure 1).

Figure 1: Schematic description of development pathways in drylands



Credit: Millennium Ecosystem Assessment

Advances in science and technology and their application in the development of resilient land use systems that are adapted to climate change can provide a pathway out of this poverty cycle. This needs to be supported by enabling policies and political will; public awareness of the long-term benefits of conservation technologies; capacity building and institutional support; and above all partnerships, since many of these challenges transcend borders and are beyond the capacity of any one institution or country to cope with.

I would like to highlight how the application of science and technology can make a difference in monitoring and assessing land use and desertification and providing solutions.

Monitoring and assessing desertification and land degradation: evaluating states, trends, causes and impacts on stakeholders

Basic information is needed on the condition of the land, and the trend, or direction it is heading. The drivers of change also need to be determined so that policies to combat desertification, land degradation and drought can address the root causes. We need methodologies for gathering such information and for building human and institutional capacities to get the job done.

Different levels of information are needed by decision makers operating at different scales such as local, national and global. These scales are not independent; impacts at one scale affect those at another scale. Approaches to monitoring and assessment need to collect the information at these different levels in a coherent way so that comparisons and contrasts can be made across locations and information can be aggregated to assess national and global trends.

Information is needed not only on the biophysical changes, but also on how those changes are perceived by different stakeholders, how those stakeholders react to the changes and the impacts on different stakeholder interests. Lessons are at hand from major projects in the field carrying out such actions today, for example the Land Degradation Assessment in Drylands (LADA) Program, which is very active in our host country Argentina, along with five other large countries in all the major dryland-affected regions of the developing world.

I would like to cite a couple of examples of how ICARDA is harnessing the powers of geographic information systems (GIS) and remote sensing in identifying and targeting desertification and land degradation at different scales.

The first is the use of GIS in integrating different indicators to map resource endowments: different resource indices were developed, quantified and merged into a single index (the Agricultural Resource Potential Index, or its opposite, the Agricultural Resource Poverty Index). This is a scaled index that allows comparison between places in terms of agricultural resource endowment (climate, irrigation water, topography and soils). The method considers all relevant biophysical factors and permits consistent comparisons between different locations, since all indices have a common scale. It can be applied using currently available GIS global datasets.

A similar approach of combining different indicators was used to identify human induced salinization in irrigated areas. Analyzing trends and the factors involved can provide information on vulnerability and assist in developing early-warning mechanisms.

The advantages of using of remote sensing is that the observation of land use change is direct and can be done at different scales, from sub-continental to local using different satellite platforms and aerial photography. Land degradation can be inferred from the analysis of trends over time. It can be used to detect large-scale land use change and land degradation trends and identify 'hotspots' with significant changes or degradation.

Using a time series of advanced, very high resolution data and a calculated Normalized Difference Vegetation Index (NDVI) aggregated into monthly NDVI composites, ICARDA identified changes in both natural and agricultural vegetation. In North Africa this indicated the extent of deforestation for irrigated and rainfed cropland in the coastal zone, and also a second trend inland where both rainfed and irrigated land had reverted to barren and sparsely vegetated areas.

At the other end of the scale, a local case study assessed land degradation in a farming community in Syria. The approach combined the assessment of changes in land use between 1958 (using aerial photographs) and 2000 (using Landsat imagery) with interviews with older farmers. Results showed that irrigation had expanded into previously rainfed land; rainfed agriculture had expanded into what was previously rangeland; both the area and quality of rangelands had been reduced; fallow periods had been reduced from one year in two in 1958 to one year in four in 2000; and farmers perceived fertility decline as the main form of land degradation. The next step will be to work with farmers in combating loss of fertility.

Solutions: combating desertification

Decision makers want to monitor and assess more than just the size and scope of the problem. They also want solutions. These solutions must be monitored and assessed to confirm whether they are working, or how to adapt or adjust them if needed. A good example of monitoring and assessing sustainable land management solutions is carried out by the World Overview of Conservation Approaches and Technologies programme (WOCAT). WOCAT's tools and approaches have recently been integrated into the LADA methodology so that an integrated program is now monitoring and assessing both the problem and the potential solutions.

Again, let me share a couple of examples of sustainable land management solutions. Studies of land degradation in the Central Asian Republics have revealed a complex of interrelated problems: soil erosion due to poor soil conservation practices; soil salinity; low soil fertility due to monocropping or sub-optimal cropping patterns; and water shortages due to drought, losses through poorly maintained irrigation canals and inefficient water use. The arable area in the Aral Sea basin in Uzbekistan has been halved since 1990 due to severe salinization. Identified solutions include minimum tillage, uniform laser-assisted land leveling in irrigated fields, diversification of wheat monoculture with other crops, and salinity management by planting on raised beds using machinery developed in India, resulting in improved soil fertility, reduced soil erosion and higher production.

The use of conservation agriculture based on the principles of minimum soil disturbance (zero tillage) and leaving crop residues (stubble) on the land combats soil erosion and leads to better soil structure and soil moisture conservation as well as saving energy and fuel in machinery use. While conservation agriculture is widely practiced in some regions such as in the Americas and Australia, uptake has been slow in other regions due to a lack of locally-available low cost machinery. In India, appropriate equipment has been developed for smaller fields, and in the Near East ICARDA is working with farmers and local manufacturers in developing and testing suitable equipment.

In the dry areas, sustainable water management is equally as important. Drivers to conserve and optimize water productivity involve different issues at different scales.

- At the basin level we need to consider competition among uses (agricultural, industrial and domestic); transboundary issues and competition between countries; and equity issues between upstream and downstream users within a watershed.
- At the national level decisions are driven by the considerations of competition among uses (agricultural, industrial and domestic), agricultural production, food security, welfare and environmental concerns.
- At the farm level, users' objectives are to maximize economic returns, which may not consider the real cost of the water they use.

ICARDA's research focuses on sustainably increasing water productivity at both the farm and basin levels. ICARDA has adopted a community-based approach, directly involving communities of land and water users in problem analysis and the identification and testing of potential solutions in representative benchmark sites in different agro-ecologies.

In the rangeland sites research has focused on the development of mechanized micro-catchment water harvesting. A comprehensive database was developed on soil and water resources, topographical, biophysical, environmental and socio-economic information. This information was combined in a GIS to develop suitability maps for water-harvesting techniques based on available biophysical and land ownership indicators. Laser-guided machinery was used to establish micro-catchments on contours. The introduction of water harvesting combined with grazing management has had a visible impact, even with two consecutive years of drought, on vegetation cover (grasses and shrubs) and diversity, the soil seed bank and organic matter and reduced soil erosion.

In rainfed systems we are investigating the use of supplemental irrigation at critical times of moisture deficit. Deficit irrigation was found to increase the productivity of the water (crop yield per unit of water) as well as productivity per unit of land. Water valuation studies were also conducted to develop optimal and water use practices that maximize farm incomes while securing sustainable water resources.

Concluding remarks

In conclusion we have seen how advances in science and technology are used in monitoring and assessing states, trends, causes and impacts of desertification and land degradation. Such scientific monitoring and assessment provides the basis for remedial and preventive action by combining that information with available technologies to develop solutions to combat land degradation and drought.

However solutions depend on the local context of environment, policies, markets, capacities and cultures. Since solutions are implemented by land users and other stakeholders they need to be involved in choosing the ones that they think will best fit their needs, capacities and interests. And, finally, policy and institutional options need to be developed that will enable end users to adopt sustainable resource management technologies and practices.

Monitoring and assessing the causes of and potential solutions to land degradation must therefore involve social and economic as well as biophysical assessments. This must include: the characterization of land users' livelihoods and risk management strategies; quantification of the determinants of poverty; analysis of community institutional arrangements; participatory and community-based approaches; and analysis of policies and institutional structures. Finally, we need to ensure that knowledge accumulated from those solutions and the lessons learned are continuously and systematically documented, shared and reproduced.

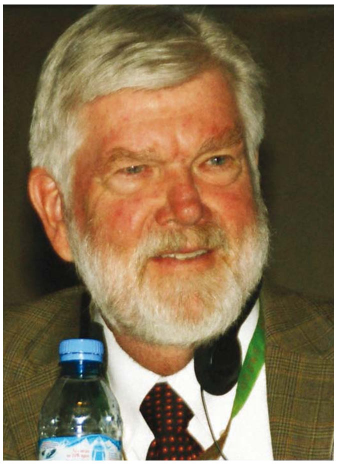
Mr. Chairman, I hope this brief overview has provided a feeling for some of the key topics and issues that we need to address. Our task is enormous and our goal is ambitious: to harness advances in science and technology to provide the UNCCD with the information needed to improve the monitoring and assessment of desertification, land degradation and drought, and to develop solutions. With that aim in mind, I very much look forward to the deliberations in this conference.

Thank you.

Working Group 1 session
Integrated methods for monitoring and assessment of desertification/land degradation processes and drivers

Chair: ***Charles Hutchinson***, *University of Arizona, USA*
Rapporteurs: ***Jürgen Vogt*** *and* ***Stefan Sommer***, *JRC/IES, Ispra, Italy*

Rapporteur's overview



Credit: IISD/Earth Negotiations Bulletin

Charles Hutchinson

In the first keynote presentation Dr. Youba Sokona presented the policy-relevant aspects of the Working Group 1 White Paper. He illustrated the monitoring and assessment needs of different user groups and highlighted that despite differences related to their differing spatial and temporal scales of interest, most users require similar types of monitoring and assessment information.

He stated that considerable experience in monitoring and assessment of desertification processes exists but that there is a lack of harmonization and a lack of spatial and temporal continuity in data and information flows. More integration of information from different sources is needed. Through examples he explained that institutional agreements at all levels (sub-national, national and international) are needed to assure adequate quality and continuity for meaningful monitoring and assessment and that initiatives for stakeholder integration have to start at the national level.

He noted that there is synergetic use of monitoring and assessment systems that already exists under other environmental conventions, so the development of a complementary dryland observation system is needed for the efficient monitoring and assessment of DLDD. He also pointed out that the monitoring of land components of environmental condition is very limited, and is needed by all the environmental conventions.

Finally, Dr. Sokona highlighted that the establishment of a global dryland observation system (GDOS) would reinforce these synergies through coordination, harmonization and extension of monitoring and assessment specific to DLDD.

In the second keynote presentation James Reynolds (Duke University) presented an integrated, science-based framework for monitoring and assessment of desertification. He argued that the complexity of DLDD issues requires the integration of human (H) and environmental (E) factors and consideration of their interactions across nested scales.

He proposed and elaborated in detail a framework for an integrated analysis of human–environment interactions and desertification processes. This framework consists of six steps, from general concept definition and initial scoping, through variable and indicator selection, to integration and assessment. These steps should be applied iteratively by a monitoring and assessment system addressing drylands globally and at multiple scales. He illustrated the implementation of this framework through examples.

Prof. Reynolds then related this framework to the idea of establishing a global dryland observation system that would build on and complement existing observation systems while providing a focus on drylands and on desertification issues. Finally, he highlighted the integration of local environmental knowledge as an important aspect of monitoring and assessment for desertification.

The Executive Secretary of the UNCCD, Mr. Luc Gnacadja joined part of the session. He welcomed the conference participants and confirmed the importance of the new conference style in the implementation of the 10-Year Strategy.

Discussion

The keynote presentations triggered considerable plenary discussion. We are grateful to the discussion points raised by the delegates and scientists from Argentina, Belgium, Bolivia, Brazil, Chile, China, Cuba, Guinea, Holy See, India, Mali, Mexico, Niger, Philippines, Senegal, Yemen, UNEP and the World Meteorological Organization (WMO). The following key issues emerged and were highlighted in a lively debate:

1. Definition of land degradation and desertification

The definitions of land degradation and desertification as provided by Working Group 1 were challenged as being different from the official UNCCD definitions. Also, the fact that desertification was defined as an end state of a land degradation process was questioned.

Working Group 1 agreed that the process dynamics has to be in the focus, but said that the definitions provided do not conflict with the UNCCD definition of desertification, as the entire DLDD context is addressed. The definitions provided are based on a strict scientific reasoning in order to provide a clear basis for monitoring and assessment and are not meant to contest the UNCCD definition as such.

2. Problems related to data accessibility and data cost

Problems of data accessibility and data costs were underlined. Working Group 1 explained that this issue is implicitly covered by the request for an open and consistent data policy as explained in the White Paper of Working Group 1. It has been noted that the problem is also apparent in many other contexts and that the only practical way is to start with the available means and capacities and continue to work in parallel on an improved provision of resources and technology transfer. In this context the importance of training and capacity building was emphasized.

3. Synergies between monitoring and assessment systems of the Rio Conventions

The complementary nature of monitoring and assessment efforts under all Rio Conventions and the consequent need to develop synergies was emphasized, including adequate support to monitoring and assessment efforts in the countries. The proposal of a GDOS could be perceived by parties to lead to an increase of workload/ burden. Therefore it is important to harmonize reporting systems of different conventions to avoid duplication. The monitoring and assessment of DLDD should further consider issues of climate variability versus climate change and integrate topics such as drought and forest decline as proposed for the 5th Assessment Report of the Intergovernmental Panel on Climate Change (IPCC).

4. Use of local environmental knowledge

The need to include local environmental knowledge and institutional capacities of affected countries in the monitoring and assessment process was highlighted in the presentations. The strong involvement of private landowners and indigenous groups (and a participatory approach in general) were advocated in order to bridge the gap between science and technology and decision makers. In this context, due consideration of rights of land ownership (eg as they affect sustainable land management) as well as the utility of information not only for decision makers but also for those affected, were underlined.

5. Need to harmonize country approaches

Several delegates highlighted the need to harmonize approaches by different countries including the need to propose elements for monitoring and assessment at different geographical scales and administrative levels. The Chinese experience and institutional foundation was mentioned as a good example for a successful national monitoring and assessment program, underlining that monitoring and assessment must be localized, continuous, authoritative and scientific, and that monitoring and assessment effectiveness needs to be regularly evaluated.

6. Importance of an integrated monitoring of human and environmental systems

The importance of integrating human–environment systems interactions, as presented by Working Group 1 as a basis for monitoring and assessment, was widely supported and the need for education was underlined as a key issue of implementation in this context.

7. Thresholds or tipping points for reversibility/resilience

The question of how to identify and document thresholds or tipping points for the reversibility/resilience of a system was discussed. It was agreed that in practice this is very difficult. The combined use of both local environmental knowledge and scientific knowledge was seen as critical in this context.

8. Selection of most important indicators and relationship to the minimum set of impact indicators

The selection of the most important indicators in relation to slow variables was discussed. It was clarified that there is no final list and that the right indicators have to be flexibly selected according to the scoping and synthesis steps described in the monitoring framework that was presented.

9. Relationship between impact indicators

Clarification was sought on the relationship between the minimum set of 11 impact indicators under the 10-Year Strategy, as proposed by the Informal Experts Group and the work of Working Group 1. Working Group 1 underlined that integrated monitoring and assessment should include information on progress and impact of measures and that it supports the minimum set of 11 impact indicators proposed by the Informal Experts Group as a starting point.

At the same time Working Group 1 pointed to the urgent need for selecting appropriate indicators based on clear, accepted, scientifically-based concepts and for further enhancements in using indicators in the context of the Convention and its future implementation. The proposed monitoring framework should facilitate this on a scientific basis. The chairman of the Informal Experts Group stated that the recommendations of Working Group 1 are not in conflict with the findings of the Informal Experts Group report and that the human–environment systems approach is well suited for further advances on indicators.

10. Standardized approach to addressing and evaluating ecosystem services

It was further debated whether there is a standardized approach to address and evaluate ecosystem services as a basis for monitoring and assessment. The response was that a number of evaluation systems of DLDD and ecosystem services have been developed. Examples were given from Australia and New Mexico.

11. Need for publication efforts and coordinated research networks

The need to encourage scientists to enhance efforts to publish on DLDD was underlined, including the need for raising more public awareness on the issue and the support for coordinated research and efficient networks.

12. Role and functioning of the proposed scientific body

Concern was expressed that the proposed new science bodies may absorb the resources of parties, which are urgently needed for building national monitoring and assessment capacities. It was further asked whether the proposed scientific body should mirror the IPCC model or a different one. It was highlighted that there are different options and that Working Group 3 has elaborated the issue in more detail.

Working Group 1 keynote presentations

Working Group 1, keynote presentation 1

Integrated methods for monitoring and assessing desertification/land degradation processes and drivers: highlights of policy-relevant aspects

***Youba Sokona**, Executive Secretary, Sahara and the Sahel Observatory (OSS)*

Credit: IISD/Earth Negotiations Bulletin

Youba Sokona

Context

Desertification is recognized as one of the major threats to the global environment, with direct impacts on human well-being and social welfare (Millennium Ecosystem Assessment 2005). This presentation aimed to review how systems for monitoring changes in the state of land at different scales, combined with modern methods of data management, analysis and assessment, can help policy makers and environmental managers to evaluate past decisions and provide a rational basis on which to base future decisions. Indeed, integrated monitoring and assessment has been identified as one of the major challenges for adequately combating desertification (Berry et al. 2009).

Many experiences are available and continuing efforts are underway for the monitoring and assessment of DLDD at operational scales. However, approaches are still isolated, dispersed and not yet sufficiently harmonized. In addition, up to now, there is a lack of satisfactory monitoring and assessment of DLDD at the global scale. Many challenges, such as difficulty in accessing data and information, are hindering improvements in the implementation of the UNCCD. Efficient strategies for making periodical assessments of the state and evolution of desertification, for providing scientifically validated data and information on early warning, and for evaluating the performance of management programs, are therefore highly relevant to the proper implementation of the 10-Year Strategy of the UNCCD.

User clusters and their information needs

Scientifically validated data and information on the state and trend of DLDD processes are needed by a diverse group of users, including local, national, supra-national and global policy makers, scientists, land managers, the media and society at large.

Providing appropriate information at the correct spatial resolution, level of detail, and in a format suited to each user's need, is critical for both sustainable land management and policy formulation. Failure to provide appropriate information in a usable format will hinder progress in the implementation of the UNCCD and handicap stakeholders at all levels. Also, analyzing the costs of establishing a monitoring and assessment framework against the costs resulting from inaction would further help decisions on the most appropriate and economical course of action.

Although data collection methods and analysis procedures may change from local to global scales, most users at all levels broadly need to know:

- the spatial extent, severity and trends of desertification processes over time: where is desertification taking place?
- the nature of the process: which ecosystem services are being degraded?
- the causes of desertification and possible actions to counter it: why is desertification taking place and what can be done to prevent or reverse it?
- the risk of areas changing their land degradation status and becoming desertified
- the costs, in terms of opportunity costs of lost ecosystem services, as well as prevention, rehabilitation and reclamation costs
- the social consequences that result from desertification.

More specifically, the following stakeholders require particular types of information as follows:

- **Global policy stakeholders.** This group needs to lobby for global and national support for programs to combat desertification, and therefore need information to support their motivations for interventions. Their information requirements are most appropriately presented as a combination of global maps and tables that can justify international investment into combating desertification. The Parties to the UNCCD are the key stakeholders at this level, along with the UNCCD Secretariat.
- **Supranational stakeholders.** Information requirements at this level are similar to those of the global level but need only to be specific to the relevant group of countries; this generally implies a higher spatial resolution.
- **National governments.** Information needs to be country-specific and at a greater spatial resolution than the global or supranational data. There is also a greater need for country-specific drivers of the desertification process and how this relates to the national policy framework. Repeatedly mapped data on the extent, location and severity of desertification is needed to provide early warning of emerging problems, assist in the prioritization of interventions, and assess the success of policies.
- **Local authorities.** It is at this level where direct resource allocation is made for the implementation of projects on the ground. Therefore, the specific information needed for direct targeting of interventions are more focused on practical issues (nature, location, duration, roles and responsibilities etc), on appropriate approaches for projects and/or programs' implementation, and on monitoring and evaluation of projects and/or programs.
- **Land users/owner households.** This is the key level at which sustainable land management initiatives are implemented and where the individuals directly invest their own resources and time into land management. Therefore, a participatory mapping of desertification, the specific remedies to deal with DLDD, the costs of various options to deal with it, the land tenure situation, and prospects and options for external assistance are the key information required at this level.
- **Other user clusters.** These include society at large, the development and scientific community, and the media. While the scientific community can digest large data volumes without any support for interpretation, society at large has a keen interest in the causes and consequences of DLDD, appropriate mechanisms to tackle it, governmental policies and initiatives aimed at combating DLD, potential consequences of inaction, and the need for resources and assistance. The media group, however, is ready to use a variety of information but mainly that which raises people's awareness and targeted information for various audiences.

Assessing the extent of DLDD

Assessing the extent of DLDD requires the consideration of a number of issues, including:

- the integration of biophysical and socio-economic information
- an adequate surveillance system combining ground observation with remote sensing
- permanent and dynamic mechanisms to ensure a constant flow of science-based information to stakeholders
- the setting-up of institutional arrangements that guarantee the quality and usefulness of products as well as the continuity and sustainability of monitoring systems; these agreements should also contribute to breaking institutional compartmentalization and enable harmonization and the use of common metrics
- the translation of scientific knowledge or findings into intelligible, jargon-free, pithy messages which policy/

decision makers find relevant and credible; this should be promoted by a two-way communication channel between scientists and policy/decision makers for effectiveness and the usefulness of information on DLDD.

Inducing potential synergies

There are considerable potential synergies that might be realized through collaboration among UN environmental conventions and more specifically between the climate change convention, the biodiversity convention, the desertification convention, and other international agreements. These potential synergies are: i) scientific, recognizing the physical, ecological and socio-economic linkages that tie them together, and: ii) institutional, recognizing the complementary and often overlapping objectives in the programs that are implemented to pursue their respective goals.

The potential benefit of collaborative action across conventions has been recognized since the conventions were conceived, and a number of mechanisms have been put in place to facilitate cooperation among them. Unfortunately, none of these mechanisms has achieved that objective so far. Therefore, there is an urgent need to:

- renew efforts to invigorate the mechanisms that have already been put in place to facilitate collaboration among the conventions
- establish a GDOS to serve as a visible focal point for collaboration, supported by the establishment of scientific networks
- use these vehicles to reinforce relationships that have been established with other global environmental conventions (eg Ramsar, World Heritage Center, Migratory Species, Collaborative Partnership on Forests).

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Working Group 1, keynote presentation 2

An integrated, science-based framework for monitoring and assessing desertification/land degradation processes and drivers

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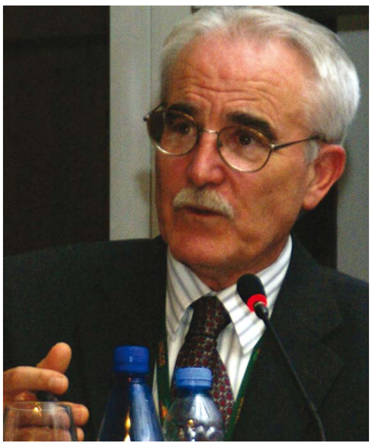
Context: Land degradation and desertification

The UNCCD defines desertification as "land degradation in arid, semi-arid, and dry sub-humid areas resulting from various factors, including climatic variations and human activities". Expanding on this, we view desertification as the end state of the process of land degradation that results in the long-term failure to balance the demand vs. supply of ecosystem services that are necessary to sustain human livelihoods, as elaborated by the Millennium Ecosystem Assessment (Box 1).



Credit: IISD/Earth Negotiations Bulletin

James F Reynolds

A key feature of most dryland areas is that there is a very tight, direct coupling between humans (**H**, livelihoods, culture, recreation etc) and their environment (**E**, eg climate variability and natural resources, for instance, through collecting firewood, drinking water, hunting game, raising livestock, growing crops etc).

Persistent, substantial reduction in ecosystem services may be the result of human and climatic factors (eg excessive cutting of wood, over-cultivation, poor water management, drought, over-grazing) and is a much greater threat in drylands than in non-dryland systems (Millennium Ecosystem Assessment 2005b). When defining land degradation in terms of the balance between demand and supply of ecosystem services it is important to keep in mind that human needs change over time and that the viability of livelihoods depends upon a range of services – thus the whole *basket* of services must be considered rather any single one in isolation. The objective of land restoration or sustainable land management therefore must be to optimize the whole *basket* of services.

Land degradation in drylands will undoubtedly expand substantially in the future as a consequence of climate change and projected population growth rates. Given that about 38% of the total global population lives in drylands, and desertification currently impacts the livelihoods of some 250 million people in the developing world (Millennium Ecosystem Assessment 2005b), this is a crucial global environmental change concern.

What is needed for an integrated analysis of desertification?

The UNCCD receives comparatively little exposure in the popular and scientific media compared to the other two conventions: the United Nations Framework Convention on Climate Change (UNFCCC) and the Convention on Biological Diversity (CBD). We argue that this is largely due to the absence of a focused international science program (Reynolds et al. 2007) and, therefore, propose a scientific research framework that consists of three major, complimentary components:

1. ***Integrated conceptual framework:*** decisions should be based on coupled human–environment systems, due to the need to account for dynamic interactions and feedbacks between the biophysical system components and human management.
2. ***Integrated monitoring:*** efficient strategies for assessments of desertification status, early warning signals and evaluating management programs.
3. ***Integrated assessment:*** the availability of a suite of integrated forecasting tools to assist decision makers.

A six-step roadmap

In this section we present a six-step roadmap that links the three components of our proposed scientific research framework.

Step 1: Integrated Framework: the Dryland Development Paradigm

An interdisciplinary group of scientists recently proposed a new synthetic framework, the Dryland Development Paradigm, or DDP (Reynolds et al. 2007). This consists of five principles:

P1: Human–environment systems are coupled, dynamic and co-adapting, so that their structure, function and interrelationships change over time.
P2: A limited suite of 'slow' variables determines fundamental changes in human–environment system dynamics.
P3: Thresholds in key slow variables define different states of human–environment systems, often with different controlling processes.
P4: Coupled human–environment systems are hierarchical, nested and networked across multiple scales.
P5: The maintenance of up-to-date local environmental knowledge is key to functional co-adaptation of human–environment systems.

In drylands there is a close dependency of human livelihoods on the environment, and both parameters are very dynamic, meaning that the interrelationships between H→E and E→H are always changing (P1). This close dependency of livelihoods on the environment may impose a high cost if the human–environment linkages become unbalanced or dysfunctional due to variability caused by biophysical factors as well as markets and policy processes (see P3 below). Each subsystem has external drivers and internal functioning, and critical linkages between each are created by human decision-making on the one hand (H→E) and the flow of ecosystem services

Box 1: Types of ecosystem services vital to sustain human livelihoods in drylands (after Millennium Ecosystem Assessment 2005a).

Provisioning services are products humans obtain directly from ecosystems, such as *food* (plants, animals), *fuel* (eg wood, dung) and *freshwater*.

Regulating services are the benefits from ecosystems, such as *erosion regulation* (adequate plant cover helps retain soils etc), *climate regulation* (land cover of ecosystems influences temperature, precipitation, the sequestration and emission of carbon etc), and *water regulation and purification* (land cover influences runoff, flooding, aquifer recharge, filtering of organic wastes etc).

Cultural services are the non-material benefits people obtain from ecosystems through spiritual enrichment, recreation and aesthetic experiences.

Supporting services underpin all the other services. They often indirectly impact people and occur over long time periods and, once severely disturbed, are difficult (sometimes impossible) to reverse in drylands. Examples include: *soil formation* (eg provisioning services depend on soil bulk density, organic content) and *nutrient cycling* (eg nitrogen, phosphorus that affect soil fertility).

on the other (E→H). As a result, ecosystem goods and services of importance to local populations are changing and evolving over time (Millennium Ecosystem Assessment 2005a).

Principle two (P2) emphasizes the importance of 'slow' or controlling variables in both H and E domains. For example, terrestrial primary production is dependent on both soil moisture and nutrients; however, nutrients in the soil change very slowly over time (a 'slow' variable) whereas the residence time of soil water changes very rapidly (a 'fast' variable). Slow variables are important because they actually control changes of state, while fast variables usually reflect unimportant variability within states. At any given time, the degree of soil fertility would be more important to a management decision than soil water content (the latter will change within hours). Similar examples exist for social-economic variables (Walker and Meyers 2004).

Thresholds involving the slow variables play an important role in drylands (P3) (Stafford Smith et al. 2007). If a threshold is crossed this can lead to unbalanced or dysfunctional human–environment linkages as discussed above (P1). Furthermore, the capacity of human–environment systems to recover from the impacts of crossing undesirable thresholds as a result of land degradation is often slow and transaction costs are non-linearly related to the degree of degradation (P3).

Principles P1–P3 of the DDP (slow and fast variables, thresholds, and constant changes in the interactions and balance of human–environment interactions) all depend on the scale of interest (P4). For example, are we interested in the welfare of a single household, an *ejido* (in Latin America, a communal land shared by all people of a community) or a nation? In managing human–environment systems such cross-scale linkages are important in decision-making, but in drylands these linkages are often remote and weak, requiring special institutional attention and monitoring support (Reynolds et al. 2007; Stafford Smith 2008).

Links between the human–environment sub-systems are mediated in practice by human mental models and local environmental knowledge (P5). Differing management and policy decisions are often dependent on local environmental knowledge although 'local knowledge' per se is not always very local: it may be the knowledge of distant policy makers about how their institutions operate as much as local farmers' understanding of the effects of different levels of grazing. A monitoring system that aims to detect whether the future management of a human–environment system is likely to be effective needs to monitor slow variables in the H and E components, but also track local environmental knowledge and the processes available to help update this crucial knowledge over time (see Step 5).

Step 2: Scoping process

The DDP in Step 1 is a conceptual framework. Scoping is a methodology that converts such a conceptual framework into a 'real world' analogue based on stakeholder participation that encourages sharing of knowledge about local land degradation issues. While most would agree that the legitimacy of achieving a workable policy-based model can only be realized by the involvement of stakeholders, identifying who they actually are is not a given. Anyone with direct or indirect interests may wish to be involved, eg local farmers, local and/or regional government policy makers, businesses, land owners, non-governmental organizations, community organizers and so forth. The process of scoping usually takes much iteration, since stakeholders have differing assumptions and biases regarding the drivers and consequences of degradation. Furthermore, stakeholder engagement ranges from passive participation through cooperation, consultation and collaboration to collective action.

Nevertheless, when stakeholders and decision makers with diverse backgrounds participate in the conceptual stage of formulating a model, this tends to eliminate ambiguities and logical inconsistencies and focus attention on the main processes and the state variables most crucial to the problem at hand. In fact, experience in such brainstorming exercises reveals that a transdisciplinary approach, including societal groups and non-scientific experts in the knowledge generation process, is pivotal for the development of practically relevant solutions to the problems at hand. In other words, the fundamental inter-relations of social and natural processes need to be made transparent to non-scientists as well for progress to be made in model development.

Lastly, the scoping process can be a useful way to guide scientists to key variables regarding the structure and functioning of the coupled human–environment system of interest (Step 3). This also aids in understanding stakeholder priorities, desired endpoints, and potential conflicts when selecting indicators.

Step 3: Selection of variables to monitor

To fully describe the current state or condition of coupled human–environment systems, biophysical and socio-economic indicators that wholly or partially summarize the entire system are needed. Indicators are either individual or sets of *measurable variables* selected to provide a broad, quick and easily understood overview of the current state of the human–environment system with regard to its land degradation status. For example, in the Heihe River Basin of northwest China, Shanzhong and Fang (2006) developed hydrological indicators of desertification using two groups of measurable variables: *surface water* (including runoff, channeling) and *groundwater* (declines, changes in water quality).

Indicators may be based on a wide range of human–environment variables, such as available water resources per capita, population density, per capita income, soil loss, nutrient balance, crop production, net primary production, carbon storage, livestock units per area, habitat condition and so forth. All of these are typically composed from fundamental datasets like precipitation, temperature, population data, slope, soil properties, salinity, albedo (reflection from the Earth's surface), biomass measurements, livestock numbers, land use, protected areas, landscape fragmentation etc. Results from the synthesized knowledge models derived through the local level participatory process that includes local environmental knowledge (see P5) should also be incorporated.

In summary, to select the most appropriate indicator(s) is a difficult, but important, challenge. We stress that the selection process must be *flexible*, *adaptive* and *innovative* in order to best represent local and/or regional drivers of land degradation.

The principles of the DDP frame two key implications for monitoring drylands using indicators. First, any monitoring system should be nested (ie at different levels of interest, where each is a subset of a higher one) and where the design at each scale addresses the needs of decision makers at that scale, but is linked to the other scales by a common theme or goal (P4). This will enable meaningful comparisons by decision makers of information gathered at local, regional and national scales.

Second, the common themes or goals of the aforementioned nested approach to dryland monitoring should be based on variables representing key ecosystem services (see Box 1), especially in relation to the various types of decision that humans make. Ideally, the selection of indicators to be monitored at each scale should engage the affected stakeholders (Step 2).

The context of land degradation, especially in terms of specific stakeholders' interests, must always be foremost in the minds of decision makers when selecting indicator variables (Step 2) as well as scale (Step 4). Geist and Lambin (2004) carried out a worldwide review of the causes of desertification and identified four major categories of proximal causal agents: i) increased aridity; ii) agricultural impacts, including livestock production and crop production; iii) wood extraction, and other economic plant removal; and iv) infrastructure extension, which could be separated into irrigation, roads, settlements, and extractive industry (eg mining, oil, gas). They concluded that only about 10% of the case studies were driven by a single cause (with about 5% due to increased aridity and 5% to agricultural impacts). About 30% of the case studies were attributable to a combination of two causes (primarily increased aridity and agricultural impacts), while the remaining cases were combinations of three or all four proximal causal factors.

Generalizations about the extent and degree of desertification over large areas can therefore be misleading. Credible assessments can only be obtained by accessing key human–environment indicator variables (P2), including a mixture of field measurements of vegetation and soil variables, local indigenous knowledge, high-resolution aerial photos, satellite images, and a range of socio-economic factors (P1).

Step 4: Scaling and integration

The DDP recommends focusing on 'slow' or controlling variables and their thresholds, rather than 'fast' variables that are responding to noise driven by variability in the system (P2). The definition of 'slow' or 'fast' is scale-dependent, that is, slow variables at one scale may be fast variables at another scale and vice-versa. For example, debt to equity ratio or grass basal area may be slow variables at the household/farm scale, but fast variables when considered at a national scale, where they are nested within other related 'slower' variables such as interest rates or land use patterns.

In less variable environments, fast variables can be reasonable indicators of underlying slow variables. In moist pastures, for example, annual grass production is quite stable and is a reasonable indicator of the status of underlying soil properties. In dry rangelands, however, annual grass production is too noisy to permit the detection of change in underlying productivity measures such as grass basal area or soil water holding capacity.

There may be a case for monitoring fast variables for some specific purposes, but this should not be the primary focus in a desertification monitoring system (Step 3). For example, instantaneous food availability may be important for detecting where a famine is going to occur this year and requiring outside aid; but longer-term measures of food productivity and household income levels (slower variables) provide much more stable indicators of which regions are becoming more or less resilient to future drought shocks. Hence, desertification monitoring (as opposed to emergency aid monitoring) should be focused more on the latter type of slower variables.

Nesting slow variables in consistent 'ecosystem service' themes permits some data to be scaled-up. For example, the theme of grazing production might be indicated by plant cover and percentage composition of specific palatable plant species at a local level. The species selected must be appropriate to the locality and the underlying thresholds at which undesirable change will occur (eg a certain loss of plant cover), which may depend on local mean rainfall and soil type. In turn, this might be accompanied by a measure of average grazing pressure and household income mean and variability, and indebtedness.

These variables could be collated to a national level to indicate the proportion of localities with palatable plant species composition and plant cover above locally-determined thresholds, and linked with the proportions of households with incomes above a certain threshold. Remotely sensed values of vegetation cover by landscape type could be used to help provide regional context for these human–environment variables.

Lastly, these data could potentially be scaled-up to provide regional indicators across nations of where grazing production may fail in future, and linked to other indices of household income to project poverty vulnerabilities with changing populations.

Step 5: Integrated assessment

The goal of our scientific research framework is to integrate scientific knowledge of all types (human–environment) to accurately represent and analyze real world problems of land degradation and desertification that will be useful for policy makers and decision makers. To accomplish this requires a trans-disciplinary approach, as these problems rarely observe disciplinary boundaries.

Integrated assessment is not a single method, model or approach but akin to a toolbox from which a very broad spectrum of approaches can be drawn upon in creative ways to accomplish the integration of complex issues, such as land degradation and desertification. Integrated assessment involves all relevant components of a human–environment system that can be considered for the benefit of stakeholders and decision makers.

Metaphorically, integrated assessment is akin to solving a puzzle (Rotmans and van Asselt 2001), that is, each stakeholder can often see the separate pieces of the puzzle, but "the real art is fitting them together in such a manner that a logical whole arises, which is more than the sum of its parts". Integrated assessment offers a systematic approach that can help identify gaps in knowledge, which have often frustrated the development of realistic policy analysis of desertification to date.

Integrated assessments have increasingly been used to ask critical questions that represent new directions of research in the trans-disciplinary sciences. Ultimately, what distinguishes integrated assessment from interdisciplinary research is its policy dimension, that it embraces complexity, multiple spatial and temporal scales, and readily incorporates uncertainty, all of which are fundamental elements for human–environment dryland systems.

The value of integrated assessment is its ability to convey innovative and (often) counterintuitive insights into real world problems, rather than necessarily attempting to 'predict' the future per se. It involves a diverse number of approaches and skills, as required in Steps 1-6, including participatory approaches, scoping, and modeling. In fact, given the uneven state of scientific knowledge of coupled human–environment systems, and differences in stakeholder needs and perceptions, integrated assessment is an excellent general tool for the assessment process.

Step 6: Global monitoring system for drylands

Many scientists have argued for the establishment of a global monitoring system for the data and indicators to be collected in Step 3. The GDOS as proposed by Verstraete et al. (2011) would facilitate repeatable and harmonized measurements to meet standardized objectives, enable the archiving and availability of these data – thereby supporting research and development – and would help in the assessment and quantification of adoptive policies.

GDOS is envisaged to support the implementation of the Desertification Convention, through the provision of targeted information to key stakeholders such as the UNCCD Secretariat, the CST, and regional and national offices and departments responsible for the drafting and implementation of National Action Plans to Combat Desertification (Verstraete et al. 2011). Specifically, GDOS would provide the framework for collecting information useful for policy making as well as environmental management.

GDOS does not replace existing systems but helps capitalize on them by providing tools and techniques to integrate, benchmark, analyze and exploit already available data, as well as promote new data acquisition and the standardization and sharing of these resources. GDOS would focus on integration and the addition of missing but complementary components to a global monitoring system.

Concluding remarks

The Desertification Convention contains a number of positive elements, for example stakeholder participation. However, the challenge of developing a scientific research framework as discussed here – and turning policy discourses into concrete action plans – will require a convergence of insights and key advances drawn from a diverse array of research and knowledge in the fields of desertification, vulnerability, poverty alleviation and community development. It is also important to involve more scientific disciplines and to facilitate ways for these scientists to work across disciplines in order to produce more diagnostic and pragmatic explanations of the phenomenon of desertification.

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Working Group 2 session
Monitoring and assessment of sustainable land management

Chair: *Ephraim Nkonya, International Food Policy Research Institute (IFPRI), Washington, DC, USA*
Rapporteur: *Christopher Martius, ICARDA, Tashkent, Uzbekistan*

Credit: M. Go, IFPRI

Ephraim Nkonya

Rapporteur's overview

Following the Chair's opening comments, two keynote presentations were given, by Pedro Machado, Empresa Brasileira de Pesquisa Agropecuária (Embrapa), and Hanspeter Liniger, WOCAT. These were followed by two targeted commentaries by Johannes Lehmann, Cornell University, and Michaela Buenemann, New Mexico State University. Mr. Nkonya then opened the floor for discussion, ably facilitated by Bertus Kruger.

Dr. Machado summarized Working Group 2's discussion of a working definition of sustainable land management. It sought connections to the work of the Millennium Ecosystem Assessment, which argued for attention to the services that ecosystems provide that matter to people. However the complexities of different stakeholder valuations of those services made rendered such a definition problematic. Ultimately Working Group 2 decided to apply the World Commission on Environment and Development (1987)'s definition of sustainability to sustainable land management viz. "the management of land to meet present needs without compromising the ability of future generations to meet their own needs."

Dr. Machado also briefly highlighted the numerous advances underway in the monitoring and assessment of sustainable land management. Changes in land use such as the types of vegetation being grown (crops, trees and rangelands) are often indicative of changes in the sustainability of land management. Remote sensing, for example can detect many types of land use change, and even some changes in land *management* when accompanied by ground-truthing. Such remotely sensed data can be gathered in a very cost-effective way on the large scales that decision makers at national and international levels (eg UNCCD) seek. Dr. Buenemann later added insights on the range of sustainable land management parameters that remote sensing could detect, both human and environmental.

Other important determinants of vital ecosystem services are more difficult to detect, however. Soil nutrient stocks, especially carbon, nitrogen and phosphorus, require direct field sampling. However, models can be derived from studies at benchmark sites and extended (with validation) to similar agro-ecosystems elsewhere.

Models become especially important for parameters that are too costly to directly measure at the high frequency needed to satisfy assessment needs. Carbon is a good example: increases in soil carbon increase the sustainability of agriculture while at the same time being a sink for atmospheric carbon, combating climate change. Dr. Johannes Lehmann later reinforced this point by describing how such models can be utilized for purposes of monitoring and assessment of sustainable land management.

Dr. Liniger described practical efforts underway for the monitoring and assessment of sustainable land management through the WOCAT program and its partner programs LADA and DESIRE. Historically more attention has been paid to land degradation monitoring and assessment than to the monitoring and assessment of sustainable land management. The monitoring and assessment of sustainable land management needs to be mainstreamed in projects and activities related to land management.

He noted that much knowledge exists on sustainable land management, including knowledge of sustainable land management in actual use around the world as documented in WOCAT's databases, but there is a lack of standardization of methodology in different projects and programs, which frustrates our ability to construct a consistent global picture. He proposed a number of methodologies developed by WOCAT, LADA and DESIRE as candidates for global standardization.

Investments are needed to address knowledge gaps, assess the benefits received from sustainable land management (economic, social and environmental), and raise public awareness about the importance of sustainable land management. The UNCCD should play a catalytic role in mobilizing the vigorous engagement of the world's scientific community on this topic.

Discussion

The main discussion points arising from the question and answer session are summarized below.

Credit: C. Martius

Bertus Kruger

1. The draft recommendations related to sustainable land management seem to read as summary points of the White Paper studies, rather than as clear, simple recommendations that the Parties can pursue. Working Group 2 took this comment on board and agreed to rephrase these points as clearer recommendations for action.

2. Stakeholders should be consulted within the monitoring and assessment of sustainable land management process. Working Group 2 fully agreed. More detail on how such consultations can be successfully carried out is considered to be a topic related to the management of knowledge, particularly local stakeholder knowledge, and is therefore addressed in the Working Group 3 session.

3. Geospatial methodology and in particular remote sensing cannot detect human and social actions that have major impacts on DLDD. Working Group 2 considers ground-truthing to be an essential accompaniment to remote sensing for the monitoring and assessment of sustainable land management, including seeking an understanding of human actions and motivations. It also notes, though, that important progress is being made in the use of remote sensing and GIS to detect human/social indicators of key parameters, such as poverty/wealth, market access, policy effects that create distinct patterns across administrative boundaries, and many others. Remote sensing cannot entirely replace ground-level investigations but can be an important aid in the understanding of human and social dynamics.

4. Should the monitoring and assessment of sustainable land management focus on mitigation of climate change as the session seemed to imply, or should it focus its attention on adaptation to climate change? Working Group 2 responded that sustainable land management contributes to both adaptation to, and mitigation of, climate change. Sustainable land management increases carbon stocks in the soil, contributing to mitigation; but at the same time it increases crop yields and makes farming systems more resilient to climatic variability, improving adaptation to climate change.

5. How can we even talk of the monitoring and assessment of sustainable land management when sustainability is a long-term phenomenon – won't it require very long-term data? Working Group 2 responded that monitoring and assessment should be a long-term strategy, but even in the short term we can monitor and assess indicators of underlying processes known to be important for sustainable land management, such as carbon, water, nutrient and biodiversity elements. We can also monitor and assess the adoption of land management practices that are likely to deliver sustainable land management.

6. The monitoring and assessment of sustainable land management needs to take into account the impacts into, and out of, the dryland system under study, because sustainable land management in drylands does not operate in isolation. For example, mountains in non-dry areas are 'water towers' that supply the drylands, and erosion in drylands is carried by rivers to non-dry and coastal areas downstream. Working Group 2 accepts this comment as accurate. One aspect central to the monitoring and assessment of sustainable land management is attention to land use systems at landscape scales and across borders, which captures some of these issues. Nevertheless, conscious attention to impacts from and to external ecosystems needs to be taken into account within the monitoring and assessment of sustainable land management.

7. Sustainable land management depends on interactions between many components (vegetation, soils, management etc) and therefore the monitoring and assessment of sustainable land management cannot rely on simple one-dimensional indicators. Working Group 2 feels there needs to be a balance between simple but incisive indicators and more complex but realistic indicators. The scientific literature does indicate the existence of repeating patterns of cause–effect in the realm of DLDD and sustainable land management. These patterns often reflect coupled human–environment interdependencies that could in principle be identified by indicators, adding important insights into system dynamics that have so far gone unrecognized.

8. The conservation of biodiversity *in situ* is difficult and is a battle that is being lost on many fronts. It needs to be backed up by gene banks to ensure that biodiversity is preserved. Working Group 2 agrees with this comment; *in situ* and *ex situ* genetic conservation are complementary, not alternative options.

Working Group 2 keynote presentations

Working Group 2, keynote presentation 1

Monitoring and assessment of sustainable land management: overview of issues

Pedro Luiz Oliveira de Almeida Machado, Embrapa Rice and Beans Center, Brazil

Credit: IISD/Earth Negotiations Bulletin

Pedro Luiz Oliveira de Almeida Machado

Defining sustainable land management

The literature abounds with different definitions of sustainability, and there are many definitions of sustainable land management. Our Working Group 2 purpose is not to review that literature, but rather to devise a working definition that is suited to the purposes of monitoring and assessing sustainable land management in the context of the UNCCD.

Most definitions of sustainable land management emphasize the maintenance of ecosystem services for providing desired functions over a specified time horizon. But what are the 'desired functions' of the UNCCD?

The 10-Year Strategy of the UNCCD, which began in 2007, echoes the link between people's well-being and the environment. Its first two strategic objectives address these two dimensions, and the first expected impact that it lists places high hopes on sustainable land management as a way to combat DLDD. Each expected impact links environments to people:

- to improve the living conditions of affected populations
- to improve the condition of affected ecosystems and
- to generate global benefits through effective implementation of the UNCCD.

Clearly, the UNCCD wishes to emphasize combating the adverse impacts that desertification has on poor people, and a key way it envisions doing so is through sustainable land management.

The Millennium Ecosystem Assessment's desertification synthesis and dryland systems analysis (Millennium Ecosystem Assessment 2005a and 2005b) provide a relevant way to connect ecosystem services to the UNCCD's pro-poor orientation. The Millennium Ecosystem Assessment recommended monitoring and assessing "things that ecosystems provide that matter to people" which it proposed in four main categories of *ecosystem services*:

1. provisioning services – goods produced or provided by ecosystems such as food, fiber, forage, water etc
2. regulating services – benefits from regulation of ecosystem processes such as water purification, climate moderation etc
3. cultural services – cultural benefits from ecosystems such as tourism, recreation, aesthetic etc
4. supporting services – these underpin the services above such as soil, biomass production, carbon, nitrogen, nutrient cycling etc.

Despite these apparently straightforward definitions, it is apparent on subsequent reflection that different stakeholders will value such services differently. Environmental conservation groups especially value features of sustainable land management that preserve the natural heritage of landscapes and ecosystems. Farmers desire sustainable land management that ensures productive and profitable use of soil and water resources for growing crops and raising animals. Urban interests place high value on sustainable land management that protects them from floods, water shortages, landslides, reservoir siltation and dust storms. Businesses are concerned with maximizing the generation of revenues from land. Global planners desire simple macro-scale sustainable land management interventions that are amenable to international negotiation, tracking and accounting. And local interests prefer customized and contextualized sustainable land management that optimizes the benefits they receive.

In keeping with UNCCD's pro-poor focus, power relationships in such negotiations should not be allowed to disenfranchise the poor, whose very survival may depend on the land's ecosystem services. However, even that focusing instrument does not eliminate ambiguities. Do the poor all agree among themselves on what services they need? Who shall be the judge of which land uses ultimately benefit the poor most? In some cases, large-scale investments in land development could benefit the poor through higher-paying employment or more productive agriculture, for example. In other cases, the poor may be worse off.

Since a useful working definition must be simple, straightforward and practical, Working Group 2 decided that its definition needed to avoid such complexities. Working Group 2 therefore decided to parallel the World Commission on Environment and Development (1987)'s definition of sustainability, adopting a working definition of sustainable land management as "the management of land to meet present needs without compromising the ability of future generations to meet their own needs."

This definition focuses the monitoring and assessment of sustainable land management on a 'do no irreversible harm' basis, erring on the side of caution since the needs of future generations cannot be assumed in advance. Irreversible damage to major ecosystem components and services such as biodiversity, soil quality, water supplies and other 'slow' but difficult or impossible-to-reverse variables (see preceding paper by Reynolds) would violate this working definition. Therefore the monitoring and assessment of sustainable land management should be as effective as possible in identifying and measuring such trends and risks.

A reference frame for the monitoring and assessment of sustainable land management

Observations of changes in land use are consequently highly informative of sustainable land management trends that indicate shifts in ecosystem services, and often impact human well-being. Furthermore, land use change is relatively straightforward to measure in a monitoring and assessment regime. Therefore, measurements of the related parameters below are prime instruments in the toolkit for monitoring and assessment sustainable land management:

- Land *use* change: changes in major categories of human use of the land (eg conversion of pasture to cropland, forests etc)
- Land *cover* change: changes in the extent or type of vegetation covering the land surface
- Land *management* change: changes in how the land is managed within the broader land use categories (eg from ploughed to zero-till system).

Advanced scientific methods for the monitoring and assessment of sustainable land management

Ecosystem services, human well-being, and stakeholder negotiations are all complex and difficult parameters to measure, and can be expected to vary in complex ways over time and space – while interacting with and affecting the trajectories of each other. Natural resource assets that are 'invisible' to direct human observation, such as carbon and nitrogen pools and fluxes and hydrological cycles, can only be effectively assessed using advanced instrumentation, modeling and data analysis.

Remote sensing is a leading methodology with valuable applications for investigating land use and land cover change. Combined with GIS, remote sensing can aid the analysis of social and economic drivers of sustainable land management by linking spatial patterns to human processes on the ground ('socializing the pixel') and vice versa ('pixelizing the social').

Remote sensing entails the acquisition of information about the Earth's surface without actually being in physical or intimate contact with it. The science offers tremendous potential for monitoring and assessing the sustainability of land management, providing spatial, spectral and temporal perspectives that cannot be obtained from ground data. It can also provide information on the spatio-temporal dynamics of biological productivity indicators, including biomass, crop yields and net primary production. Global net primary production data have been operationally available as Moderate Resolution Imaging Spectroradiometer (MODIS) and Advanced Very High Resolution Radiometer (AVHRR) products, since 2000 and 1982 respectively.

However, ground-truthing and remote sensing must go hand in hand. Fieldwork is needed to calibrate algorithms for maps and for assessing map accuracy. Contextual knowledge acquired in the field can be used to orient the analysis, for example to determine whether a gain or loss of woody plants (eg bush encroachment, deforestation, afforestation) is viewed as an improvement or degradation in sustainable land management in the eyes of stakeholders.

Fieldwork also provides ancillary data on environmental and human conditions that cannot be derived through remote sensing. When linked with remote sensing data, such field data can be used to offer qualitative or quantitative explanations for observed land surface changes. Quantitative assessments via spatial models require field data that are associated with geographic coordinates and that were collected using a spatially meaningful sampling scheme.

Key natural resources underpinning sustainable land management

Certain natural resources, such as water, soil organic matter, structure, vegetative cover and nutrients are key assets for sustainable land management. Having insufficient quantities of these assets often constrains the functioning of ecosystem services and contributes to irreversible degradation. Thus they are strategic points for monitoring and assessing sustainable land management.

Water

Water is the defining natural resource constraint of drylands. It is a basic parameter driving ecosystem productivity and biodiversity. The effects of droughts can be effectively simulated, but the problem in using these for early warning is that it is usually not possible to predict when a drought will occur or how long it will last. Long-term rainfall records can inform decision makers about the degree of variability of rainfall over the long term in particular locations, and this can be combined with poverty and related data to produce drought vulnerability maps.

Phosphorus

Phosphorus is essential for plant growth and drought tolerance, but supplies are often inadequate in dryland soils. Applications of phosphorus fertilizer are essential for raising yields in many dryland regions, for example the West African Sahel. Global reserves of available phosphorus may be depleted in about 50–100 years, with a production peak expected around 2030. Phosphorus losses into watersheds, for example through erosion, constitute a pollution problem, causing eutrophication of water bodies. Sustainable land management practices are urgently needed that improve the uptake efficiency, recycling and availability of phosphorus. The use of cover crops (mixed or in rotation) is one of a number of strategies that can help.

Soil organic carbon

Soil organic carbon affects numerous soil functions, including nutrient release, nutrient retention, soil water holding capacity, plant available moisture, water infiltration, soil tilth, soil aggregate stability, and bulk density. Soil organic carbon is therefore one of the most important supporting services enabling soil quality and health over the longer term. The establishment of a network of benchmark sites, where management practices and changes in soil organic carbon are closely monitored, is recommended to supply the data required to enhance models that can predict carbon states and trends more widely.

Connections of monitoring and assessment of sustainable land management to climate change and biodiversity conventions

The environmental issues addressed by UNCCD and its sister conventions, the UNFCCC and the CBD, are closely intertwined, and sustainable land management is fundamental to achieving the goals of all three. While there are complementarities between the environmental goals of all three conventions, trade-offs often arise in their pursuit. Integrated action on all three objectives can optimize outcomes and could improve the efficiency of monitoring and reporting, thus reducing total costs of pursuing these goals. There is much to be gained from coordinated action on the three multilateral environmental agreements when developing policy measures to support sustainable land management, and there is a need for effective interfacing and coordination of approaches to monitor and assess each convention.

Working Group 2, keynote presentation 2

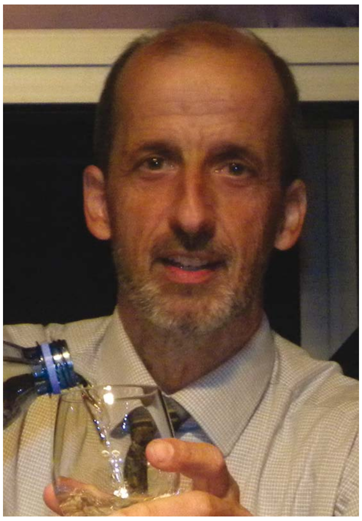
Experiences in the monitoring and assessment of sustainable land management

***Hanspeter Liniger**, WOCAT, Switzerland*

Why monitor and assess sustainable land management?

To date, most of the emphasis in monitoring and assessing desertification was placed on soil degradation and particularly on erosion. Monitoring and assessment should not only look at land degradation, but equally at the achievements made towards sustainable land management. We need to monitor and assess biological degradation such as reductions in vegetation cover and changes in the composition of plant species (eg a shift from high-value fodder to unpalatable species). We also have to include water degradation, for example reduced flows in rivers. To broaden the scope from soil to land means including soil, water, vegetation and animals – even humans. All these resources are linked.

Credit: C. Martius



Hanspeter Liniger

Monitoring and assessing sustainable land management can help us learn from experiences. There are many unrecognized sustainable land management practices that constitute a wealth of untapped knowledge that we are not using. A few examples, as documented by WOCAT[2] include:

[2] See www.wocat.net for more detailed examples

- the conversion of grazing land to fruit and fodder plots: in Tajikistan, badly overgrazed and degraded hillsides were fenced, terraced and converted to produce grapes, fruit and grass
- the famous (Zhuanlang) loess plateau terraces in China: since the 1950s, over 90,000 km^2 (an area more than twice the size of Switzerland) has been rehabilitated and made productive, while protecting the Yellow River from flooding and from siltation overloading
- no-till agriculture and conservation agriculture: these practices have spread worldwide and are used in large-scale farming areas like Australia, Latin America and the USA as well as by small-scale subsistence farmers in Africa and other developing regions
- 'Ecograze' in Australia: this ecologically sound and practical form of grazing management, based on rotation and seasonal resting, has been developed through the involvement of research (vast areas of grazing land in the world suffer from degradation and it is an urgent task to identify and spread good grazing land practices)
- Water harvesting systems: for example, the establishment of trees in drylands such as olive trees in Syria.

The most important arguments for monitoring and assessment are that it should be used for spreading sustainable land management by building on the existing wealth of knowledge (indigenous, innovative, project, research), not repeating mistakes, recognizing complexity, and understanding local fine-tuning. However, so far monitoring and assessment has been insufficient, mostly fragmented, not systematic or standardized, and there has not been any mapping of sustainable land management and its impacts until recently.

There has been a recent rush to publish success stories, such as 'brightspots' by UNEP or 'good agricultural practices' by TerrAfrica/FAO and others. But they are not easily accessible, and are difficult to compare because they are in different formats and lack the continuity that would allow them to be used for long-term monitoring.

Standard methods and tools

In the following section, a standard framework for documenting, evaluating and disseminating good sustainable land management practices is proposed: firstly for sustainable land management technologies and approaches at the local level, and secondly for mapping land degradation and sustainable land management at the local, national and global scales.

Local and field levels

At the local/field levels, two complementary methods are proposed:

a) The standardized WOCAT documentation

WOCAT has developed standardized questionnaires and a database system to document and evaluate sustainable land management technologies and approaches, a subset of which is published in 'Where the Land is Greener' (WOCAT 2007; Liniger and Critchley 2008).

Sustainable land management technologies are presented in standard 4-page summaries, all following the same format and covering the same topics. Each technology is well illustrated with photos, technical design, pictograms and a short text describing the technology. Both the natural and human environments are equally presented. For the natural environment, information such as rainfall, altitude and slopes is shown; for the human environment, information is provided about land size per household, land use rights, land ownership, market orientation, technical knowledge required, importance of off-farm income etc.

Very important are the establishment and maintenance costs per hectare (eg labor and equipment) and the short- and long-term benefits compared with costs. Impacts of sustainable land management related to production and socio-cultural and ecological benefits or disadvantages (on-site as well as off-site) are also included. The quantification of the impacts is a real challenge but crucial for the decision-making process (see below). Each concludes with the strengths and weaknesses of the sustainable land management technology. In addition to the technology the sustainable land management *approach* is described, defining the ways and means in which a technology was implemented.

Examples include the mass mobilization of land users in China, the spontaneous spread of *Grevillea* agroforestry systems in Kenya, and incentive-based catchment treatment in Bolivia. These show the wide variety of successful approaches to spread sustainable land management. Land-user participation and decision-making, as well as community involvement from initiation to planning, implementation, monitoring/evaluation and research, show crucial aspects of the sustainable land management approach.

National inventories that follow the standardized format of WOCAT have been compiled for Bangladesh, China, Ethiopia, Mongolia, Nepal and South Africa. Some of these are available as books and downloads from the WOCAT website. The data from these fact sheets can also be used for analysis and to formulate policy implications as presented by Linger and Critchley (2007).

b) The standardized LADA local assessment

The LADA project[3] has developed a local level assessment methodology that is being tested with local communities and stakeholders, in three to six pilot areas in each of the six LADA countries (Argentina, China, Cuba, Senegal, South Africa and Tunisia). This methodology is complementary to the WOCAT technologies and approaches assessment, and allows the evaluation of impacts of degradation and sustainable land management at the field level.

The aim is to improve understanding of the drivers, causes, impacts and responses in regard to land degradation and sustainable land management in specific land use systems. The 'LADA-Local' manual outlines: how to conduct the field observations, measurements and interviews of land degradation and sustainable land management with land users and key informants; the need to build on available secondary information including remote sensing images and maps; statistics and research/case studies; and how to analyze and report on the findings using a combination of frameworks (driving forces-pressures-state-impacts-responses, sustainable livelihoods, and ecosystem services) that help explore complex human–environment interactions.

Sub-national, national and regional levels

At the sub-national, national and regional levels, spatially-referenced monitoring and assessment of sustainable land management (and land degradation) is needed. So far, there are a few maps of land degradation but there are no maps of sustainable land management, none of the impacts of either. This makes it very difficult to make decisions or demonstrate the need for and benefits of sustainable land management interventions.

Two recently developed and tested methods for spatial monitoring and assessment need to be highlighted, as they complement each other and complement the local level assessment presented above:

i) Watershed module of WOCAT

The WOCAT documentation (described above) allows users to combine single technologies and approaches within a watershed and assess the combined impacts and benefits. This facilitates the assessment of off-site impacts and effects of upstream interventions on downstream areas. Most important is that the design and costs of downstream interventions can be minimized, based on upstream investments and focusing more on preventing degradation than the rehabilitation of already degraded land. This applies not only to impacts caused by the flow of water downstream, but also by wind affecting off-site areas (eg dust storms). Showing the benefits of linking upstream (on-site) factors with downstream (off-site) factors needs more attention and will help to set priorities for interventions and investments.

ii) Sub-national mapping by WOCAT/LADA/DESIRE

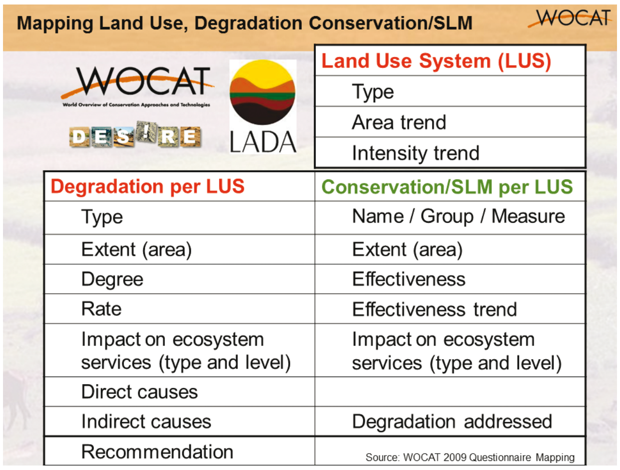
The mapping methodology jointly developed by WOCAT, LADA and the EU-funded project DESIRE[4] generates information on degradation and sustainable land management, and where to invest within a smaller or larger region. It further allows judgments about whether to rehabilitate versus whether to prevent or cure land

[3] www.fao.org/nr/lada

degradation, and what the impacts on ecosystem services are. For each land use system within an administrative unit or watershed, the area and intensity trend of the land use is assessed. Then, for each land use system, information on degradation and conservation/sustainable land management is compiled, as presented in Figure 2.

The data are compiled through a participatory expert assessment that includes local land users, supported by documents and surveys. The mapping tool is being tested and applied in six LADA pilot countries and in 16 catchments (in 14 countries) in the EU-DESIRE project.

Figure 2: Data recorded in the WOCAT/LADA/DESIRE mapping of land degradation and conservation/sustainable land management



Land Use System (LUS)
Type
Area trend
Intensity trend

Degradation per LUS	Conservation/SLM per LUS
Type	Name / Group / Measure
Extent (area)	Extent (area)
Degree	Effectiveness
Rate	Effectiveness trend
Impact on ecosystem services (type and level)	Impact on ecosystem services (type and level)
Direct causes	
Indirect causes	Degradation addressed
Recommendation	

Source: WOCAT 2007

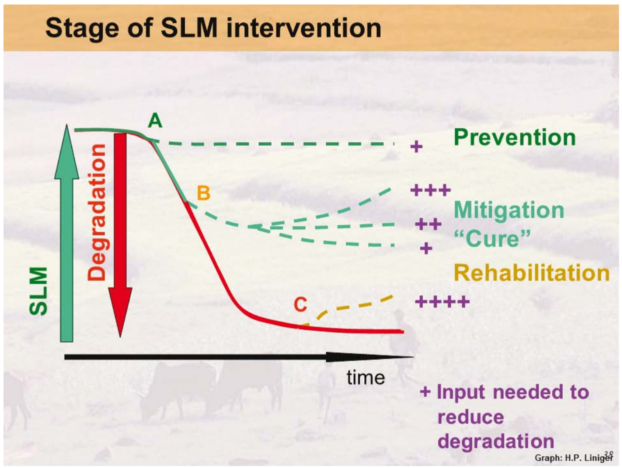
Use of monitoring and assessment for decision support

Decision makers seek answers from projects implementing sustainable land management to questions like: which sustainable land management technology and approach should be used? Where? What are the costs and impacts? Will they alleviate poverty? Will they combat desertification? Will they help people adapt to climate change?

A fundamental question is *when* to intervene: should steps be taken to prevent land degradation before it starts, or to mitigate (or 'cure') degradation after it has started, or to rehabilitate when degradation is most severe? The costs vary greatly depending on the stage of sustainable land management intervention, as shown in Figure 3.

WOCAT aims to contribute to decision support by making all of its data accessible through the Internet. In 2009, 241 sustainable land management technologies and 137 approaches from 51 countries were available in the online database. The information is also accessible via Google Earth,[5] where WOCAT symbols indicate the position of documented sustainable land management and where a summary and a link to the data pops up after clicking on the symbol.

Figure 3: Stage of intervention and related costs



Through the support of the EU-DESIRE project, a decision-support system for selecting sustainable land management practices at the local level has been developed (Schwilch et al. 2009). It covers three parts: identification of practices through a participatory learning approach; assessment of existing sustainable land management practices; and participatory selection of sustainable land management technologies using a decision-support tool (see Figure 4). The first two parts are achieved through stakeholder workshops.

All the standardized tools and methods presented have been thoroughly tested and introduced in numerous countries and contexts (especially within the WOCAT, LADA and DESIRE projects). They are open access and freely available in different languages from the project websites.

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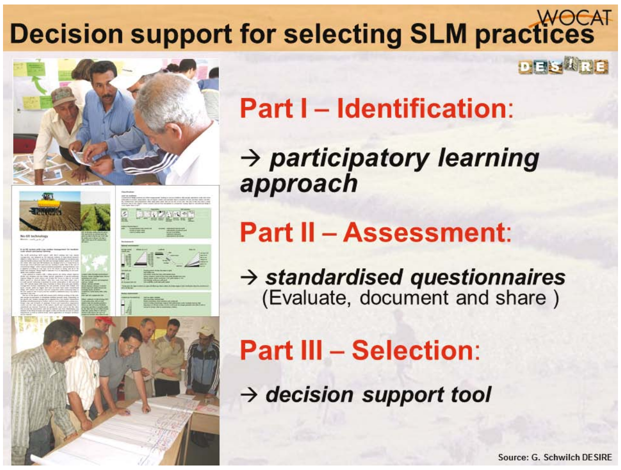
4 www.desire-project.eu
5 www.wocat.net/en/knowledge-base/slm-maps/wocat-in-google-earth.html

Research and capacity building

Experiences in monitoring and assessing sustainable land management revealed the following knowledge gaps, which need to be addressed by research:

- assessing the land area affected by land degradation and covered by sustainable land management (more involvement of remote sensing and ground-truthing is needed)
- assessing the impacts of land degradation and sustainable land management, for example on water availability and use efficiency, carbon sequestration, yield, poverty reduction etc
- long-term monitoring and modeling of land use, degradation and conservation, and the impacts on ecosystem services (see Figure 5).

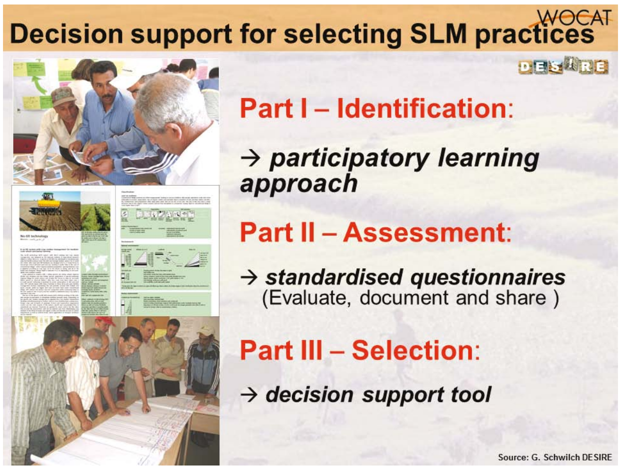
Figure 4: DESIRE/WOCAT decision-support system for the selection of sustainable land management technologies



Partnership and networking

A network of sustainable land management experts, technicians, extension workers, planners and decision makers from projects, ministries, universities, non-governmental organizations, international centers, and UN organizations and conventions provides a platform for monitoring and assessment. WOCAT has established such a network and experience has shown that the network works well when the partners are ready for collaboration, are competent and committed, have continuity, and have a critical mass. However, a heavy investment to build up the capacity for monitoring and assessment involving all stakeholders at different levels is still needed.

Figure 5: Research assessing impacts of land management practices on water loss



Source: Nieru Lewis Gitonda

Sustainable land management and global issues

Sustainable land management provides a key for addressing global issues in view of ecosystem services and human well-being. The main global issues related to sustainable land management are poverty reduction, productivity, water scarcity, climate change mitigation and adaptation, desertification and biodiversity.

A main focus of sustainable land management is the contribution it makes to maintaining or increasing the productivity of the land in view of reducing poverty and improving livelihoods for rural people. This is not only related to the production of food, fodder, fuel and fiber but also to providing sufficient and good quality water. A major challenge is to show the contribution of sustainable land management towards climate change mitigation (through carbon sequestration) and adaption. There is great potential to learn from existing experiences, for example the extent to which sustainable land management practices are tolerant or sensitive to increased temperatures, heavy rainfall events and prolonged droughts. Ongoing adaptations and innovations are already showing responses to climate change; sustainable land management technologies and approaches need to be tapped.

Additional emphasis needs to be given to monitoring and assessing the off-site effects of land degradation and sustainable land management. Increased occurrence of extreme climatic events, leading to disasters such as floods, landslides, mudflows and droughts, have national and even global impacts. The role of sustainable land management in preventing or reducing disasters must be investigated and acknowledged. Sustainable land management's key role in these global issues must be better understood and publicized.

Investment and priorities for monitoring and assessing sustainable land management

In conclusion, there is a wealth of untapped and valuable sustainable land management experience around the world, and validated methods and tools for monitoring and assessing sustainable land management exist at the local and national levels. Although solid data and knowledge is required, insufficient resources are made available to collect and utilize it.

The challenge for UNCCD and all others involved in sustainable land management is to streamline and use standard methods for monitoring and assessing sustainable land management, to build up national and global databases, and to use this knowledge to improve land use planning and decision-making. Special attention needs to be given to the assessment of impacts and to demonstrating the contribution of sustainable land management towards global issues such as climate change, poverty alleviation, reducing water scarcity and water conflicts, and achieving food security. Several knowledge gaps remain that need to be filled in order to create greater awareness of the importance of sustainable land management.

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Focus issue

Application of geospatial technologies for monitoring and assessing sustainable land management

***Michaela Buenemann**, New Mexico State University, USA*

Credit: IISD/Earth Negotiations Bulletin

Michaela Buenemann

On behalf of Working Group 2, I would like to convey one key message pertaining to the monitoring and assessment of land management sustainability and geospatial technologies: while geospatial technologies alone cannot provide the magic bullet for monitoring, assessing or optimizing land management sustainability, they can substantially improve the effectiveness of the monitoring and assessment of sustainable land management. To support this message, I will outline briefly what geospatial technologies are, why we should exploit their strengths more fully for the monitoring and assessment of sustainable land management, and how they are related to *in situ* or field applications.

Geospatial technologies are those information technologies that handle geo-referenced data (ie data with information on their absolute locations on the Earth's surface). Remote sensing entails the acquisition of information about the Earth's surface without actually being in physical or intimate contact with it, affording spatial, spectral and temporal information that cannot be obtained from ground data. It provides systematically collected, digital, spatially explicit and continuous data on the Earth's surface across the globe, both in the visible range of the electromagnetic spectrum and beyond (eg thermal infrared or microwave). Satellite imagery and aerial photography are available for periods as early as the 1970s and 1930s respectively, offering insights about historic land conditions and change that may be difficult to obtain in the absence of long-term field monitoring projects.

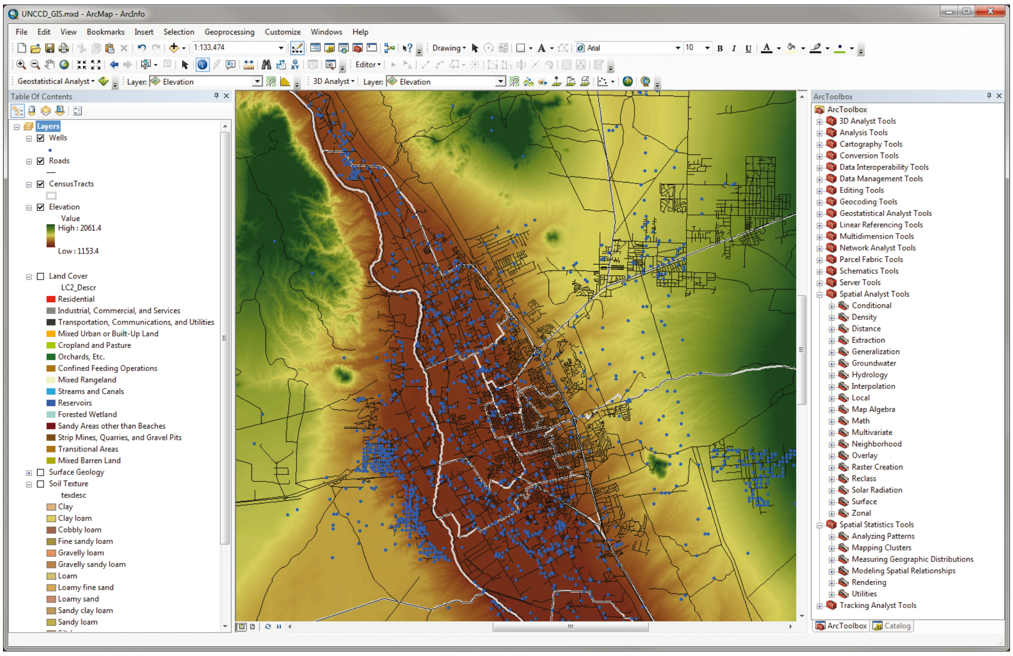
GIS are information systems that facilitate the capture, storage, manipulation, analysis, management and presentation of geo-referenced data. GIS can integrate remotely sensed and geo-referenced field data from any discipline (Figures 6 and 7). GIS can be used for map-making, querying of databases, statistical analyses and modeling, sharing of data across disciplines, and much more. Global Positioning Systems, or GPS, are another form of geospatial technology.

Geospatial technologies are invaluable for the monitoring and assessment of land management sustainability due to the very nature of land management sustainability. The degree to which land management is sustainable depends on interactions between people and the environment. Both human and environmental conditions vary across space and through time, however, resulting in complex and dynamic human–environment interactions. In other words, land management sustainability is spatio-temporally variable: what we may monitor and assess in one location and/or at one point in time may not be true elsewhere and/or at another point in time. In addition, the specific human–environment interactions that may explain land management sustainability at one spatial scale may not be at all explanatory at another spatial scale.

Assessments of land management sustainability require us to consider interactions between people and the environment as hierarchical, nested, and networked across spatial scales (local to global). Jim Reynolds (Working Group 1) explained these and other principles in the context of the DDP. The important point here is this: geospatial technologies are the only information technologies that deal with issues of spatial scale and resolution, spatial dependence, and spatial heterogeneity – all issues affecting land management sustainability.

Spatial analysis and modeling are conceptually quite straightforward. Both usually require, as a first step, the compilation of geographic data layers (eg 'maps' of elevation, land cover or population density) in a geodatabase (see Figures 6 and 7). Once the data are compiled, it is possible to apply a variety of digital computations to the data. One can perform simple measurements (eg determine length, area or shape of features); conduct queries (eg determine

Figure 6: Graphical user interface of Esri's ArcGIS software

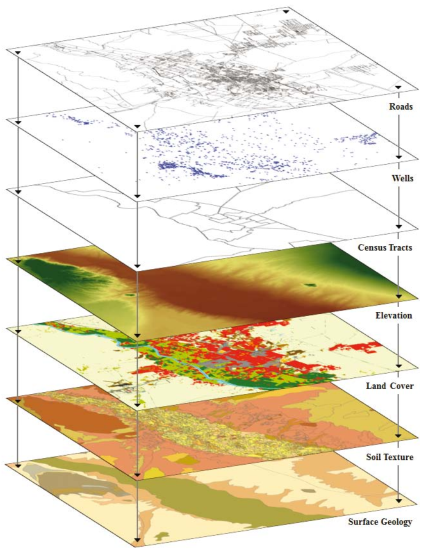


Seven layers (roads, wells, census tracts, elevation, soil type, surface geology and land cover) are included in this particular ArcMap project. Four of the layers are shown in the data view: a roads layer is the top layer, followed by a wells layer, a census tracts layer, and an elevation layer. The 'ArcToolbox' in the central part of the figure indicates some of the quantitative analysis and modeling options available in ArcGIS. Users can also examine spatial data qualitatively: for example, it is clear from the data view shown in this figure that roads and wells tend to be clustered at lower elevations.

how many people live within a specified distance of a given well); interpolate data (eg estimate the value of elevations at places where elevation has not been measured based on locations where elevation has been measured); quantify patterns (eg determine whether land degradation cases are clustered or dispersed randomly in space); optimize site selection (eg select ideal locations for afforestation given well-defined criteria such as land cover, land use, distance from settlements); or test hypotheses (eg evaluate whether a soil erosion pattern could have arisen by chance).

One can also engage in more complex modeling procedures, ie sequence a series of analysis steps to attain a specified goal. For example, one can combine geographic data layers into measures of social vulnerability to drought. One can also perform more dynamic modeling procedures to emulate processes such as land development. In cellular models, for example, each cell representing a portion of the Earth's surface changes in each simulation stage when given parameters such as the cell's state, the states of its neighboring cells, and transition rules. Model inputs (eg geographic data layers) may, of course, be changed at any time to examine 'what if' scenarios or policy alternatives.

Figure 7: The data layers in a GIS



The data layers in a GIS overlap spatially and illustrate clearly that human and environmental conditions vary across space. Spatial analysis and modeling take this variation into account, producing results (eg land management sustainability) that also vary across space.

Stakeholders can participate actively in this process: they can identify the factors to be included in the model, weight the importance of the factors, and specify how the factors should be measured. In multi-criteria decision-making models, such stakeholder inputs are combined into a single set of factors and weights to produce solutions that should be acceptable to everyone whose inputs were considered in the modeling process.

One important point that must be reiterated here is this: spatial analysis and modeling always take location into account, using spatially variable criteria as inputs and producing spatially variable results as outputs. More traditional sciences, such as statistics, fail to do this.

Pioneering initiatives (eg LADA, WOCAT and DESIRE) are already making some use of geospatial technologies. Based on the published literature, however, it is clear that we are far from capitalizing fully on the powers of these technologies. Integrated remote sensing and GIS approaches have been used to monitor and assess provisioning services (eg land cover, crop yields, water quantity and quality), supporting services (eg net primary production, soil erosion, soil carbon), regulating services (eg water runoff, climate, diseases) and cultural services (eg tourism, recreation). Various aspects of human well-being have been evaluated successfully through geospatial approaches as well (eg human health and quality of life).

Most importantly, many have now demonstrated the potentials of geographic information science and technology to serve as a common ground for collaborative, cross-disciplinary endeavors; as a platform for examining cause-and-effect relationships between variables; and as a methodological framework for the kinds of holistic assessments needed to understand land management sustainability. Studies quantifying the risk of soil degradation, land suitability for certain uses, social or biophysical vulnerability to certain hazards, or even future scenarios given alternative land management decisions in spatially explicit ways, are no longer exceptional.

Geospatial technologies alone cannot provide the magic bullet for monitoring, assessing or optimizing land management sustainability; field work is needed to inform geospatial activities. The reverse may be true as well. Field work is needed to obtain geo-referenced *in situ* data, which are crucial for both the calibration and accuracy assessment of geospatial products (eg land cover maps).

Field work also provides data that cannot be derived through remote sensing: for example, while remote sensing may tell us whether there has been a gain or loss of woody plants in an area (eg bush encroachment, deforestation, afforestation), only field work (eg interviews or surveys) can tell us how this change is perceived by diverse stakeholders.

While field work may be indispensible for geospatial work, the latter can also enhance the efficiency and utility of the former. Remote sensing can help decide which field sites should be selected for more detailed sampling, for example, and thus ensure that data collected in the field capture the heterogeneity of the study area.

It is important to reiterate that remote sensing in particular may provide information on land management sustainability that simply cannot be provided through field work alone – unlike field work, remote sensing products are not locally selective or restrictive, but are instead spatially continuous.

Geospatial approaches offer many opportunities for stakeholder participation. This has been demonstrated in a number of cases, especially those in which social scientists worked hand in hand with land users to generate, analyze and interpret mapping products. Scientists benefit from the environmental knowledge afforded by land users and often by gaining access to land that might otherwise not be granted to them. Aside from being actively engaged in the monitoring and assessment process, land users ideally benefit from the outcomes of the process. In some cases, for example, participatory mapping efforts helped resolve long-standing conflicts between villages and develop more sustainable, inter-village land management cooperation.

It is now time to more fully exploit the strengths of geospatial technologies for moving sustainable land management forward in a flexible and adaptive fashion. Geospatial technologies have been demonstrated to improve policy and decision-making for optimal land management, enable participation from local stakeholders, and fuel economic growth. Geospatial technologies are evolving rapidly and becoming increasingly available and affordable to all countries.

We therefore recommend that the UNCCD consider expanding existing and building new geospatial capacities, in manners that:

- foster collaboration and partnerships among land users, universities, the private sector, national and international organizations and networks, and others invested in land management
- ensure that international interoperability standards are met in terms of hardware and software resources
- support the development of and adherence to a spatial data infrastructure that is compatible with the emerging global spatial data infrastructure, to facilitate the discovery, accessibility, sharing, transfer, interoperability and reusability of geospatial data
- emphasize training as an integral part of the capacity-building process, whereby scientists should be trained so that they can complete standard UNCCD assessments and independently develop and apply analytical procedures aimed at solving land management problems unique to their surroundings
- improve the generation and use of best knowledge pertaining to sustainable land management.

Focus issue

Modeling as a tool for the practice-based assessment of the biophysical parameters that underlie sustainable land management

Johannes Lehmann, Cornell University, USA

Credit: C. Martius

Johannes Lehmann

I would like to comment on two groups of recommendations that Working Group 2 proposed as part of this scientific conference, both to reinforce what the keynote speakers have touched upon in their excellent presentations and to highlight specific challenges and opportunities.

The first is the desire to monitor and assess underlying biophysical factors of sustainability, such as soil health. This is desirable for various reasons, among them the need for scaling single measurements to the wider landscape by GIS supported by remote sensing, but also to explore linkages to climate change and climate change mitigation.

An important example is carbon. Sustainable land management can increase soil organic carbon, providing a whole suite of benefits to soil health (soil water and nutrient retention, nutrient availability, reduced erodability, increased microbial activity and others). At the same time it plays a major role in greenhouse gas emissions/sequestration. The quantities of organic carbon found in soil are much larger than in the vegetation and atmosphere above it. Due to the vast amounts of organic carbon in soil, even small percentage changes in this pool make large differences to CO_2 emissions from land use.

Soil organic matter is an example of what Jim Reynolds referred to earlier today as a 'slow' variable, ie amounts of carbon increase or decrease slowly over time in the soil, but with long-lasting effects on soil health. (In contrast, water and mineral nutrient contents fluctuate rapidly, so they are 'fast variables'.) Carbon is also relatively easy to measure. Given these two realities, one might think that it would be easy to monitor and assess soil carbon for the purposes of the UNCCD and the UNFCCC. However, the quantities of soil organic carbon vary so much over space and time that it is impractical to quantify to the degree of accuracy and resolution required for monitoring and assessment. Therefore, other approaches besides direct measurements are required.

We suggest using modeling approaches based on land management practices. (Those familiar with IPCC methodology will be aware of similar procedures that have been categorized into different so-called 'tiers'.) *Practice-based measurement* means that instead of measuring soil carbon or even water directly, 'practices' are monitored, for example the adoption of certain tillage practices, the use of crop rotations, or residue retention. If the underlying connection between those practices and carbon cycles is understood in a mechanistic way, then soil organic carbon can be estimated using mathematical models. This requires not only that the mechanisms are quantifiable, but that models can adjust for different locations with all their environmental and human complexity.

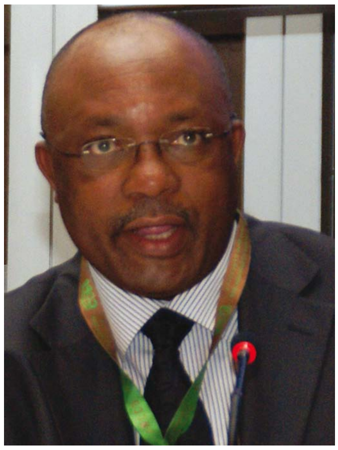
Over the past decades remote sensing tools have been developed that can help in up-scaling point measurements to create regional estimations. But modeling is only as good as the hard data and the understanding of processes that drive the model. The scientific community is at a stage where the basic understanding is at the brink of being sufficient, and where the tools are being developed to tackle the challenges that such an approach would bring. But the pieces have not been fully integrated and the understanding and tools have not been tuned to meet this demand. A concerted effort by the scientific community and donor groups are required to fully develop a practice-based approach to monitoring sustainable land management. This will require a nested approach of remote sensing, ground-truthing and modeling.

A major opportunity is to link such efforts to ongoing programs under the sister conventions on climate and biodiversity. As I mentioned before, the UNFCCC is already set up to provide some of the tools and data within the IPCC's Working Group 3 on mitigation. Several of the scientists engaged in this UNCCD First Scientific Conference work across the conventions. But a framework of support and a structure for interaction are needed to adapt and expand already existing tools and data-gathering efforts. This would not only improve the monitoring and assessment of sustainable land management; it would also benefit climate change monitoring and assessment, because a more profound understanding of the implications of land management actions on climate-relevant factors (eg soil carbon and nitrogen) is also critical to improving predictions of climate change and strategies for its mitigation in the UNFCCC.

Equally important is to ensure that strategies for climate change mitigation are sustainable from the point of view of human well-being. This was clearly expressed in the working definition for sustainability of Working Group 2. With such an approach, a longer-term vision can be developed that carries this UNCCD First Scientific Conference forward from monitoring and assessment to the simultaneous mitigation of DLDD and climate change.

Working Group 3 session
Impacts of economic and social drivers and knowledge management on monitoring and evaluation of land degradation

Chair: ***Martin Bwalya***, *New Partnership for Africa's Development (NEPAD), South Africa*
Rapporteurs: ***Mariam Akhtar-Schuster***, *DesertNet Secretariat, DesertNet Secretariat, Hamburg, Germany, and* ***Richard Thomas***, *UNU-INWEH, Hamilton, Canada*


Credit: IISD/Earth Negotiations Bulletin

Martin Bwalya

The Working Group 3 session focused on knowledge management, institutions and economics as they relate to the monitoring and assessment of desertification, and DLDD including sustainable land management. Presentations were given by:

- Mary Seely, Desert Research Foundation Namibia, Windhoek, Namibia, on 'Vertical and horizontal knowledge management: implications at the local, national, regional and global levels'
- Mark Reed, University of Aberdeen, UK, and DESIRE project on 'Knowledge management for monitoring and assessment of desertification, land degradation, drought and sustainable land management'
- Pamela Chasek, International Institute for Sustainable Development, and Manhattan College, USA, on 'Monitoring and assessment: challenges at the national and international levels'
- Stefan Sperlich, University of Göttingen, Germany, on 'Economic aspects and social drivers'.

The presentations discussed the challenges of integrating knowledge management and its practices into monitoring and assessment at various levels, from local to international, and the need for doing so. They also looked at the social and economic drivers of DLDD, and how policy mechanisms are needed in order to address these issues and produce more sustainable outcomes. The recommendations that emerged from Working Group 3 included the need for an independent, international, interdisciplinary body of scientists, working with other stakeholders, to provide relevant and credible scientific support and advice to the CST, the UNCCD and other land-related initiatives and relevant multilateral environmental agreements.

The discussion portion of the session was facilitated by Bertus Kruger. Key issues raised were:

1. How to capture and effectively share knowledge on DLDD?

Several delegates (from Argentina, China, Holy See, Mali, Niger and UNEP) addressed the issues concerning knowledge management, ranging from the need to ensure that experiences from all regions are captured and shared, to what kind of knowledge management system can be established and how can it be maintained over time. Clearly this topic fits within the UNCCD's own efforts to develop a knowledge management system. On a more philosophical level, the issue was raised (by France) on what role and impact knowledge management has on awareness of land degradation issues and the need to examine this through further research.

Concern was expressed over access to and benefit-sharing from local knowledge. Much can be gained from ongoing discussions under the CBD. It is recognized that valuable local knowledge exists and that strategies need to build on local practices rather than rely on the unsuccessful 'transfer of technology' approach that attempted to impose often inappropriate technologies to combat desertification. Delegates recognized that attempts to develop 'hybrid' knowledge management systems, whereby local and scientific knowledge can be combined, are often inhibited by institutional, cultural and language barriers, and there is a need to ensure that appropriate means of communication are employed to reach all stakeholders.

These comments reinforced the DSD recommendations (7, 8, 9, 10 and 11) to strive towards effective storage and dissemination through bodies that operate as knowledge clearing houses, at national, regional and international levels, including 'boundary organizations' that bridge institutional barriers. Support is required to encourage knowledge management hubs at national and regional scales. Coupling these knowledge management systems to early warning systems was also suggested (by Jamaica) as a way to help stimulate such hubs. The proposals on better knowledge management will facilitate the greater flow of information from knowledge-rich countries and regions to those where knowledge is less organized (eg Africa).

2. The need for a wider consideration of the economic and legal context in the formulation of knowledge management systems and mainstreaming of the UNCCD.

The lack of attention paid to the economic and legal context of DLDD issues was raised (by Chile and Saudi Arabia) in terms of the UNCCD and the material produced by the DSD consortium. Knowledge management systems need to consider the diverse interests in a globalized world, including the role of the market and how the entrepreneurial sector affects desertification. Greater efforts are required to study innovation systems in drylands and to explore the potential of the private sector to foster greater sustainable land management in cooperation with the interdisciplinary research community. An important and productive triangulation could emerge if the private and scientific sectors cooperate more closely with civil society organizations (CSOs).

3. How to scale up successes and measure/attribute impacts?

It was pointed out that projects are usually carried out in small groups at the local level, and delegates were interested in knowing how a larger scale buy-in (rolling up) can be achieved (South Africa). The idea of the creation of a network of observation systems at the global level that enable comparisons of knowledge obtained at the local level was suggested as a way forward. It was also felt that countries should be encouraged to take stock of desertification, and prioritizing or sequencing the factors at the national level (Morocco). Establishing national data and information management centers that harmonize data and that also consider traditional knowledge were mentioned by different countries (Mali, Niger, Yemen). Working Group 3 scientists responded by pointing out that an all-encompassing strategy does not exist, but that efforts to build in strategies for scaling up should be incorporated into the design phase of programs and projects.

Discussions also focused on the selection and use of indicators. Although a core set of indicators is required for comparative reasons at the supra-local level, local indicators should primarily have a meaning for local communities to improve sustainable land management. Therefore both approaches (ie local indicators and global comparability) are necessary from the scientific point of view in order to understand the complex system.

4. How to change the organization of science to encourage greater involvement of scientists in more participatory and interdisciplinary approaches?

It was observed that, in general, scientists are more concerned with publishing their work and are often reluctant to collaborate more with the rural sector (Argentina). Delegates were interested in finding out what can be done to obtain greater commitment of the research community to work with local stakeholders. Scientists responded by indicating that this attitude is slowly changing; in Europe, for example, there are already major shifts in this direction as funders search for ways to justify investments in research. The involvement of local communities and a greater adoption of more participatory, interdisciplinary approaches are therefore now expected, and are being included in research proposals.

5. The need for decision-making rules and the development and application of indicators at different scales

Delegates raised the issue of empowerment of local populations and the tools and methods needed to help them. It was suggested by the panel that agent-based modeling should be increasingly used to help understand how decisions are taken at local levels. The selection and use of common indicators of DLDD can help facilitate greater exchange of information while recognizing that some indicators will be local- and context-specific, whereas others will be useful for global comparisons. The purpose of the indicators needs to be clearly defined, ie if they are to be used for local decision-making or for comparative studies at different scales.

6. Highlighting the water issue

Several delegates (Holy See, Peru, Yemen) wished to see the issue of water scarcity being given greater prominence in the deliberations of the scientific conference. The scientists noted that under DLDD, water is implicitly included under all discussions on land. However, the Working Groups ensured that appropriate revisions to the DSD synthesis and recommendations document were made before its final submission to CST.

7. The economics of DLDD

There is general agreement that a report similar to the Stern review on the economics of climate change is urgently needed to address the costs and benefits of DLDD and sustainable land management. Delegates raised issues concerning the lack of reference to economic modeling and the inclusive considerations of monetary and non-monetary values linked to DLDD and sustainable land management. Such a report would include the bundling of ecosystem services for innovative payments for environmental services schemes in the drylands context, the alternative livelihood options such as renewable energy generation and ecotourism, and the cultural and aesthetic values of local populations.

Delegates expressed concern over an approach that considers only economic perspectives and emphasized that the complexities over global trade issues, land ownership, and the trade-offs between the environment, human well-being and economies should be included (Argentina. Holy See, Morocco, Nicaragua, Nigeria). Scientists agreed that a Stern-type report would be comprehensive and include these issues.

8. How to organize scientific information to better serve the UNCCD?

The Working Groups propose an independent, interdisciplinary scientific advisory mechanism to bring together the fragmented knowledge on DLDD (recommendations 9, 11). They further suggest that this mechanism be supported by a network of networks of scientists, including national and regional scientific bodies.

Delegates were in agreement of the need for such a mechanism, however, questions were raised as to whether it should be independent or inter-governmental (Brazil, Chile). Working Group 3 responded by indicating that the function of such a mechanism should be considered before its form. They further indicated that the mechanism is proposed as a response to the fragmented knowledge on DLDD, the many success stories at a small scale and the identification of further gaps in knowledge from a synthesis of existing experiences.

It was pointed out that the scientific community itself is now operating in a more collaborative and synergistic way, moving away from direct competition among projects. Thus there exists a coalition of scientists willing to work together to support the UNCCD and other environmental conventions on cross-cutting issues (CBD and UNFCCC). The proposed mechanism would serve as a hierarchy of scientific networks that link efforts at national, regional and international scales.

As scientists are already beginning to operate in this way, the opportunity was presented to the UNCCD to foster this development. However, it was noted that given the urgency of DLDD issues, the development of such a mechanism needs to move forward very quickly and not be subject to prolonged negotiations on its form. Initiation of a rapid consultative process is required in order to determine whether or not there is merit in these recommendations.

Acknowledgements

We are grateful to the discussion points raised by the delegates from: Argentina, Brazil, Chile, China, France, Holy See, India, Jamaica, Mali, Morocco, Nicaragua, Niger, Nigeria, Peru, Saudi Arabia, Senegal, South Africa, Yemen, UNEP and UNFCCC.

Working Group 3 keynote presentations

Working Group 3, keynote presentation 1

Vertical and horizontal knowledge management: implications at the local, national, regional and global levels

***Mary Seely, N Gaseb, P Klintenberg** and **Bertus Kruger**, Desert Research Foundation of Namibia*

Credit: IISD/Earth Negotiations Bulletin

Mary Seely

Based on the Working Group 3 draft White Paper, knowledge management is defined as: identifying existing knowledge (including data and information); new knowledge generation or production; knowledge documentation and storage; and sharing, communicating and disseminating knowledge. The challenge facing the combating of desertification includes the situation that the scientific community has been conducting research for decades while little has improved among rural communities, who are faced with decreasing productivity of degraded lands.

This is partially attributable to the results of science not being accessible to, or being used by, those who are directly addressing desertification – essentially a failure of knowledge management. Explanations for this failure include differing incentives and benefits for the scientific, land manager and user communities, and a tendency for scientists to consider information technology, websites and other electronic media as sufficient for knowledge management. This is particularly pertinent for Africa, where development has not benefited extensively from knowledge management.

Rural land users identify a variety of challenges for which they require additional information and support. These include: an increasing population depending on natural resources; non-adaptive management in highly variable environments; limited opportunities for livestock migration; and overgrazing with livestock as a cultural, economic and subsistence resource. All of these challenges, and their associated changes in livelihoods and supporting environment, involve political, social, economic and environmental elements. These factors, in turn, require an integrated research approach and appropriate, integrative supporting knowledge management.

Similarly, the effects of environmental change are identified by rural land users as: increased poverty; reduced opportunities for employment; reduced productivity in crop fields and veld (grass or scrubland); deforestation; and bush encroachment. All of these factors contribute to reduced productivity, with negative effects on livelihoods. As with the identified challenges, these are not independent factors but require integrated attention and interventions from a variety of sources.

These concerns and requirements are recognized by the UNCCD, for example the requirement of 'ensuring that the collection, analysis and exchange of information address the needs of local communities' (Article 16 of the convention). Article 16 also calls for the establishment of a 'global network of institutions and facilities for the collection, analysis and exchange of information' to 'link national, sub-regional and regional data and information centers more closely with global information sources'. While these are frequently stated and understood by all, they are infrequently acted upon in an integrated manner.

Based on examples from Namibia and the Southern African Development Community region, experience has shown that addressing DLDD depends on action from grassroots to national and international levels. Rural communities, government institutions, researchers, development agents and policy makers need to communicate while there is usually no mutual platform, as suggested below, to facilitate communication.

A variety of knowledge management platforms have been tested under differing circumstances. These include basin management committees, an approach to enhance understanding, management and decision-making with respect to land, water and other natural resources within a water basin.

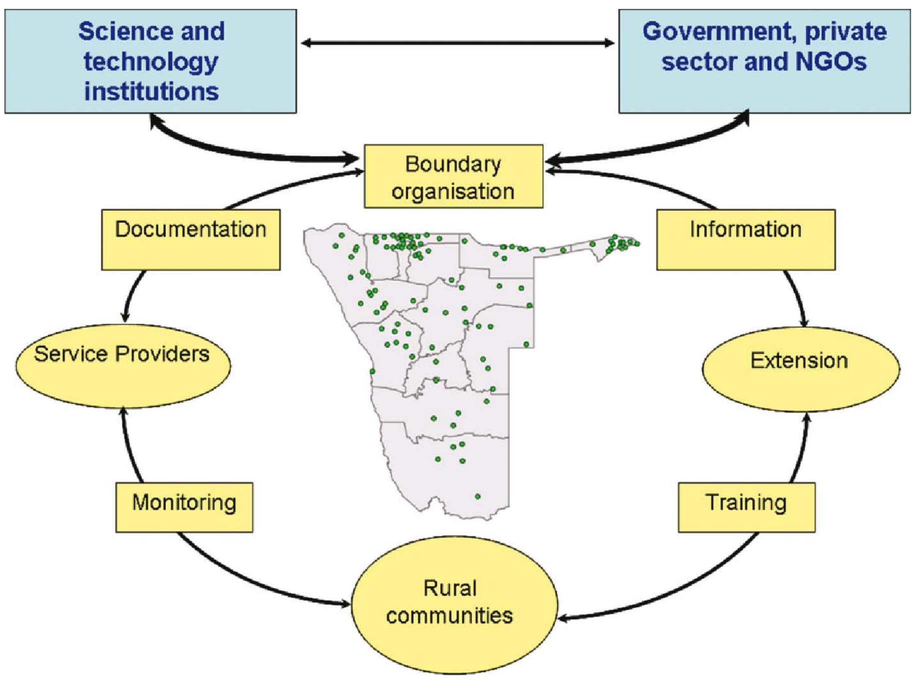
Forums for integrated resource management (FIRMs) represent an approach designed to ensure that rural farmers living on communally-managed farmlands are in charge of their own development. This involves collaborative visioning, planning, implementation and monitoring in which the relevant community-based organization takes the lead in organizing, planning and monitoring their own activities and coordinates the interventions of service providers and other partners in order to achieve the community's goals.

These approaches can be supported by community-driven local level monitoring, in which indicators are identified and developed by FIRM members; measured by farmers; interpreted and disseminated by farmers, FIRM and extension while being used for decision-making by the community and other FIRM members. The results of local level monitoring can be communicated more widely, for example, for national drought or flood warning and preparation and for climate proofing. Local level monitoring may contribute to a combination of local and scientific knowledge. On an entirely different level, a combination of scientific and local knowledge may be interpreted, for example as environmental updates in Namibia, for dissemination to parliamentarians and other high-level decision makers.

Knowledge management on behalf of DLDD/sustainable land management can be well supported by 'boundary' organizations that serve as the gathering, interpretation and synthesis platform for exchange of local to international scientific knowledge. They may serve as learning organizations for increased capacity situated at the interface among policy makers, service providers, land users, researchers and development agents, among others. Effective boundary organizations consequently contribute to more effectively addressing and responding to DLDD, climate variability and climate change while ensuring greater transparency and supporting good governance.

Boundary organizations can contribute to the diversification of sustainable land uses, for example giving due recognition to benefits of the natural-resource-based sector (including biodiversity, tourism and other alternative livelihoods) and income-generating opportunities. The following model (Figure 8) has been tested and is partially functioning in Namibia. The dots on the map represent agricultural development centers.

Figure 8: Role and distribution of boundary organizations in Namibia



In conclusion, and in agreement with the Working Group 3 paper, it is recommended to encourage and support self-sustaining communications platforms and boundary organizations, to enhance knowledge management on all levels and to strengthen human and institutional capacities to address DLDD.

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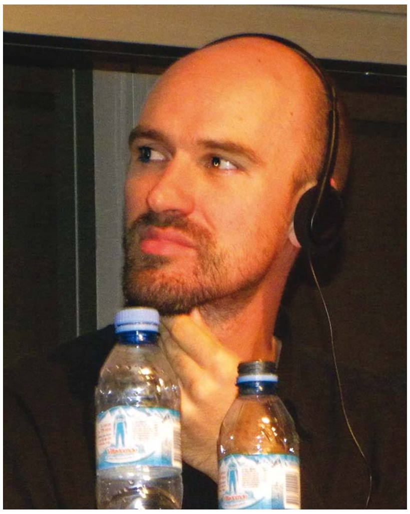
Working Group 3, keynote presentation 2

Knowledge management for monitoring and assessment of desertification, land degradation, drought and sustainable land management

Mark Reed, University of Aberdeen, St Mary's, UK

The research community can offer us many options for monitoring and assessing DLDD and sustainable land management in drylands. Discussions about how the UNCCD can best use the latest research have been going on for years, but we need to make sure that in our hurry to listen to the latest research, we do not overlook the equally valuable but often unrecognized knowledge of local communities and the civil society organizations that work with them, accumulated over generations by the people who make a living from the land we are trying to protect.


Credit: C. Martius

Mark Reed

The text of the UNCCD is unique in the way it values local knowledge. But since the Convention was ratified, we have all been struggling to work out how this sort of knowledge can actually be used, alongside scientific research, to inform the sorts of decisions that need to be made at national and international levels. Some argue that local knowledge isn't reliable enough to inform monitoring and assessment, but there are just as many who are disillusioned with researchers who got it wrong.

What we need to be able to do is to critically assess the knowledge that is available to us from each different source, whether from researchers or land managers. And then we need to draw on the most relevant knowledge available to us, combining insights from local communities, civil society organizations and scientific communities. The authors of Working Group 3 believe that by doing this, we have the potential to do monitoring and assessment more effectively and more efficiently.

Natural science breakthroughs are enabling us to monitor and assess land degradation ever more accurately at ever greater scales, ever more efficiently. But we're also learning how to work more effectively with local communities to get real change on the ground. Much of this is about learning from our mistakes. And we have made many of them. But out of a growing disillusionment with participation, a new consensus is emerging about what went wrong, and what actually works. Best practices are beginning to emerge that may enable us to harness the knowledge and power of the people, to monitor and assess land degradation. But crucially, we are also developing a new tool kit that is enabling us to integrate insights from local communities with the latest research, allowing us to get the best of both worlds.

WOCAT is helping local people share ideas about sustainable land management with communities around the world living in similar conditions. What if we could do the same thing for monitoring and assessment methods, sharing the indicators and measurement methods used by land managers around the world? And what if we linked the results of monitoring and assessment by land managers to strategies from systems like WOCAT that could treat the symptoms they diagnose, helping them live more sustainably while providing more for their families? What if this could incentivize more and more land managers to actually monitor land degradation themselves, recording information that could provide a picture of what's happening across their region or country – information that could be used at international scales?

So far, there has been a lot of attention paid to developing minimum sets of indicators to do this. There are obvious reasons why we need a minimum global set of indicators to inform the progress made towards combating land degradation at international scales. But if this information is not only going to help implement the UNCCD, but also to actually help people on the ground make more sustainable land management decisions, we must be able to supplement our minimum list with locally relevant indicators that land managers can monitor and act upon themselves.

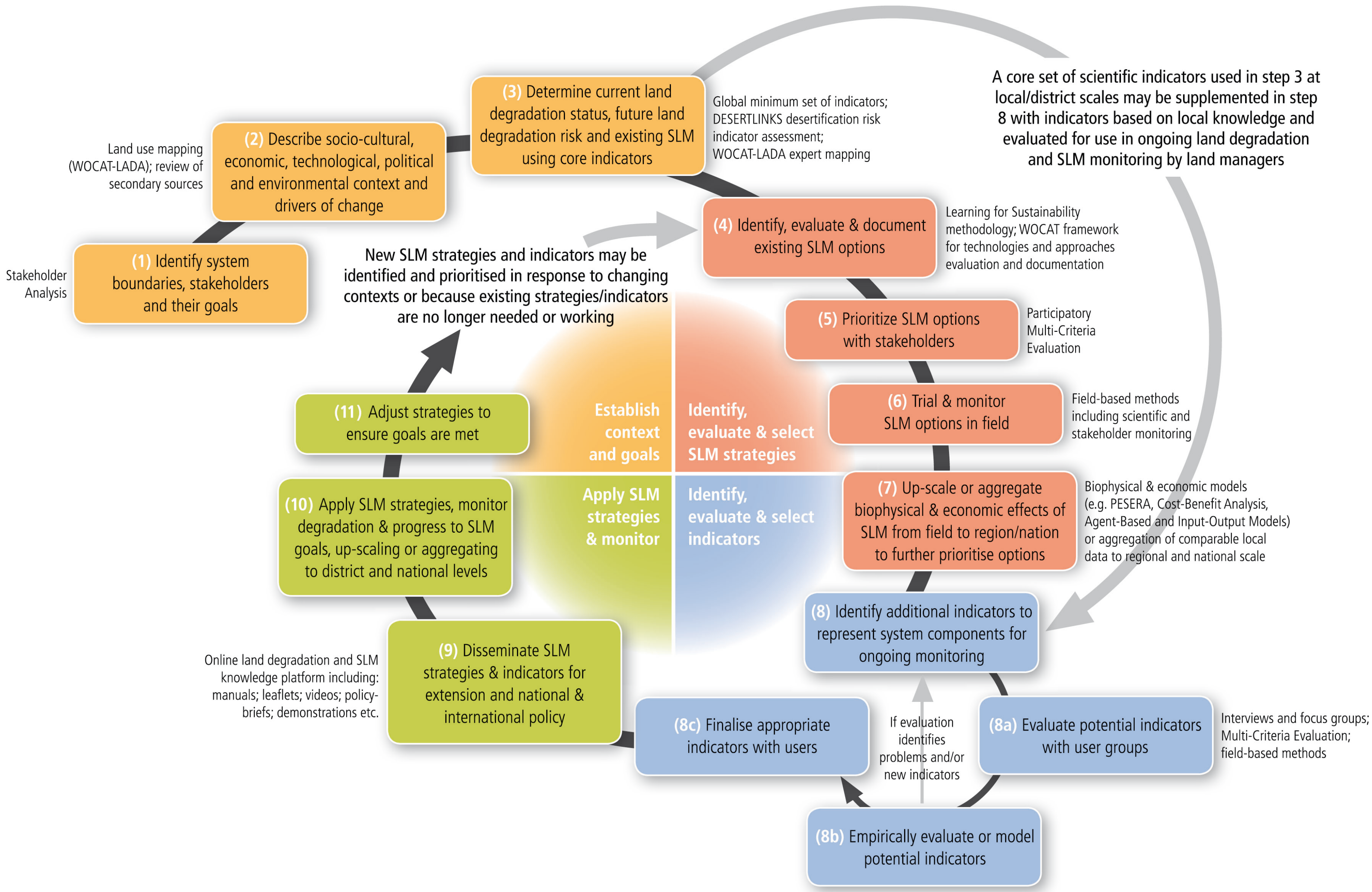
For these reasons, in our White Paper we combine elements of both the WOCAT and LADA approaches, and use these to build a new approach that can critically combine local and scientific knowledge from local to national and international scales on land degradation monitoring and assessment. Our approach builds explicitly on the methodological framework proposed by Working Group 1 to operationalize the DDP and could feed into some sort of GDOS.

In our framework, we emphasize stakeholder participation in monitoring and assessment at every step. We also emphasize the need to include the monitoring and assessment of sustainable land management in addition to land degradation, if we are to determine whether the actions we propose to address land degradation are actually working. The approach has been tested in southern Africa and is now being trialed globally through the EU-funded DESIRE project

The framework suggests that monitoring and assessment should monitor the progress of sustainable land management towards meeting sustainability goals, with results continually enhancing sustainable land management decisions. The framework is divided into four generic themes (Figure 9):

1. establishing land degradation context and sustainability goals
2. identifying, evaluating and selecting land degradation remediation strategies
3. identifying, evaluating and selecting land degradation indicators
4. applying remediation options and monitoring land degradation and progress towards goals using indicators.

Figure 9: Integrated methodological framework for land degradation and sustainable land management monitoring and assessment



This approach incorporates multiple knowledges (including land user perspectives) from local to national and international scales. In doing so, it aims to provide outputs for policy makers and land users that have the potential to enhance the sustainability of land management in drylands, from the field scale to the region, and to national and international levels through policy dissemination and sharing remediation approaches and technologies through WOCAT. We draw on operational experience from across the DESIRE project to break the four themes into a series of methodological steps, and provide examples of the range of tools and methods that can be used to operationalize each of these steps (Figure 9).

The proposed approach attempts to overcome the trade-off between the relevance of monitoring locally significant processes, and the comparability of monitoring results across wider spatial scales. Each study site selects indicators from the same minimum set of indicators to ensure comparability (step 3). These are then supplemented with indicators elicited from local stakeholders to ensure local relevance and facilitate links to sustainable land management, while supporting comparisons between sites on the basis of shared indicators from the minimum set of indicators (step 8).

Although there are increasing calls for the standardization of local indicators and monitoring procedures to facilitate comparison and communication at coarser spatial scales, we must also retain context-specific local knowledge if we are to interpret whether environmental change represents land degradation or is benign or even positive. In addition to identifying a minimum set of implementable indicators globally, it is essential to retain flexibility so that indicators can be added to ensure local relevance and can be updated to reflect environmental change. Only in this way will it be possible to capture the complexities of land degradation, and to provide outputs that are relevant to land managers and can enhance the sustainability of their land management.

As such, there is no need to choose between a top-down approach to monitoring and assessment based around a minimum set of indicators and a more bottom-up approach that is sensitive to local contexts. Instead, the framework proposes that a combination of top-down and bottom-up monitoring and assessment is more likely to achieve reliable and locally relevant assessments of land degradation and sustainable land management across multiple scales.

Working Group 3, keynote presentation 3

Monitoring and assessment: challenges at the national and international levels

Pamela S Chasek, *Manhattan College, USA; Mariam Akhtar, Schuster University of Hamburg and DesertNet International, Germany;* ***Lindsay Stringer***, *University of Leeds, UK;* ***Richard Thomas***, *UN University Institute for Water, Environment and Health, Canada*


Credit: IISD/Earth Negotiations Bulletin

Pamela S Chasek

This section of the presentation of Working Group 3's paper examines how monitoring and assessment knowledge can be better managed at the national and international levels. This presentation focuses on our review of the political and social sciences literature on knowledge management and will identify gaps and recommendations for improving knowledge management for monitoring and assessment at the national and international levels.

Monitoring and assessment of desertification and dryland degradation takes place at the national level, where governments must utilize scientific, socio-economic and technical data and information for strategic planning, priority setting and national environment and development planning, as well as in the preparation of National Action Plans for their implementation of the UNCCD.

The overarching issue faced by developing countries is lack of capacity. This key problem, identified by virtually all scientific studies and reports, ministries, agencies, non-governmental organizations and others, relates to the lack of institutional, financial and human capacity to address physical, human resources and skill requirements. Needless to say, this is nothing new. Among the challenges faced include that many capacity building programs and regions have been sectoral in nature or related to a specific treaty, but they fail to address the need for cross-sectoral capacity. In addition, once people become trained, the risk is that after a few years they have moved on because they were promoted to another position, their party was voted out of power, or other changes. The result is a clear lack of institutional memory.

At the local level, the impact of local actions, activities and lifestyles, and non-governmental organization, community and education projects do not usually take global impacts and implementation of relevant multilateral environmental agreements into consideration. Conversely, many multilateral environmental agreements do not take public participation into account sufficiently; there is little incentive for governments to do so. Collaboration among local entities, civil society and national governments needs to be improved so that there is a true bottom-up approach in implementation as well as negotiation. Experiences in Namibia and Tunisia, described in our White Paper, have been particularly successful.

We have called for the establishment of national or regional clearing house mechanisms or some other national-level 'institutional memory'. As Mary Seely has commented, this must be designed with users and contributors in mind. It must be 'live' and accessible to domestic user groups as well as national and/or regional policy makers. As has been determined in numerous studies, lack of information often leads to duplication of efforts, which often results in even more costly and often ineffective measures. Such a clearing house mechanism, while initially resource intensive, will pay off in the long run as dryland management becomes more effective. It is worth noting that several such clearing house mechanisms have already been established, but run the risk of discontinuing either once the initial funding runs out or the people involved in setting up the mechanism are no longer involved in implementation.

An example of a successful clearing house has been developed by WOCAT. Since 1993, WOCAT has built up a network of sustainable land management specialists from over 50 partner institutions worldwide. WOCAT is organized as a consortium of national and international institutions and operates in a decentralized manner. It has created a standardized system to document and collect information on sustainable land management practices, which can be used as one part of such a proposed clearing house mechanism. In countries including Ethiopia and South Africa, the WOCAT tools are already used as a standard knowledge management system at the national level. WOCAT also serves as a network of experts and practitioners at the national, regional and international scales, allowing knowledge exchange through direct contacts.

There is also a need to create opportunities for national-level collaboration between scientists and multilateral environmental agreement focal points to promote better knowledge management across multilateral environmental agreements at the national level. This could be improved by setting up national coordination bodies for multilateral environmental agreements, such as the UNCCD, the UNFCCC, the CBD and other conventions, to enable greater collaboration between scientists and focal points in the different ministries between conventions. It would also enable greater coordination of implementation and national reporting through the establishment of national databases that will allow greater information sharing and less duplication of efforts.

In addition, many national reports that are submitted to the UNCCD and other multilateral environmental agreements are never used at the national level. Therefore, there is also a need to connect reporting so that it informs national level implementation, and not just the other way around.

Knowledge management at the international level faces a different set of challenges. One challenge at the international level is to improve knowledge management between the various multilateral environmental agreements in general, and between the scientific bodies in particular. There have been numerous examples of building synergies between multilateral environmental agreements, but little has been done between the scientific bodies. For example, the UNCCD and the CBD have a Joint Work Program on the biological diversity of dry and sub-humid lands. There are also collaborations between the UNCCD and the International Tropical Timber Organization, the UNFCCC and the Convention on Migratory Species.

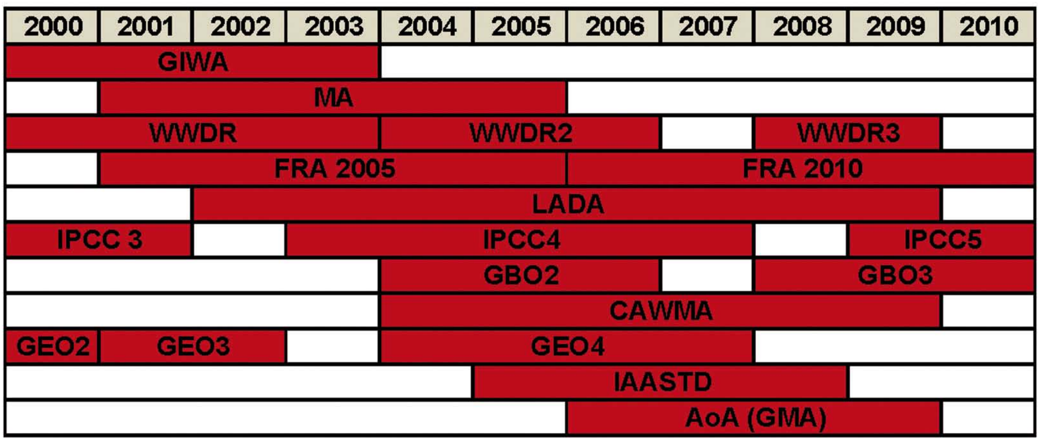
There has also been a proliferation of global assessments, including the Millennium Ecosystem Assessment, the Fourth Global Environmental Outlook, the IPCC's Fourth Assessment Report, the International Assessment of Agricultural Science and Technology for Development, the Comprehensive Assessment of Water Management in Agriculture, the Second Global Biodiversity Outlook and the 2005 Forest Resources Assessment (see Figure 10). Each of these and other regional and national assessments uses a different conceptual framework for assessment design and implementation, which has contributed to the challenges in bringing coherence to these processes. Greater international cooperation among the bodies responsible for these assessments would improve this process, as well as improving land management at the ground level.

At the international level there is also a need to improve knowledge management between the UNCCD, especially the CST and other scientific work, and relevant international and regional institutions and agencies involved in related research on DLDD. Within the UN system they include FAO, the United Nations Development Programme (UNDP), UNEP, WMO, the World Food Programme (WFP) and the United Nations Educational, Scientific and Cultural Organization.

Funding agencies like IFAD, the World Bank, GEF, and the regional development banks that provide funding for projects and programs are also important. Outside the UN system, similar organizations include the Organisation for Economic Co-operation and Development (OECD), Club du Sahel, the Arab Center for the Studies of Arid Zones and Drylands, the Arab Organization for Agricultural Development, ICARDA, ICRISAT, OSS, and the Organisation for Economic Co-operation and Development, among others.

One way to improve international knowledge management for monitoring and assessment is to create a new independent, multidisciplinary body of scientists to work alongside the CST and other bodies to publish regular science reviews. This body would provide an opportunity for the scientific community and other stakeholders with knowledge on DLDD and related issues, such as non-governmental organizations and the private sector, to proactively provide relevant and credible scientific support to the UNCCD in conjunction with the CST and other land-relevant initiatives and multilateral environmental agreements.

Figure 10: Multitude of global assessments



GIWA – Global International Waters Assessment; **MA** – Millennium Ecosystem Assessment; **WWDR** – World Water Development Report; **FRA** – Forest Resources Assessment; **LADA** – Land Degradation Assessment; **IPCC** – Intergovernmental Panel on Climate Change; **GBO** – Global Biodiversity Outlook; **CAWMA** – Comprehensive Assessment of water management in agriculture; **GEO** – Global Environmental Outlook; **IAASTD** – International Assessment of Agricultural Science and Technology for Development; **AoA (GMA)** – building the foundations for a Regular Process for the Global Reporting and Assessment of the state of the marine environment, including socio-economic aspects.

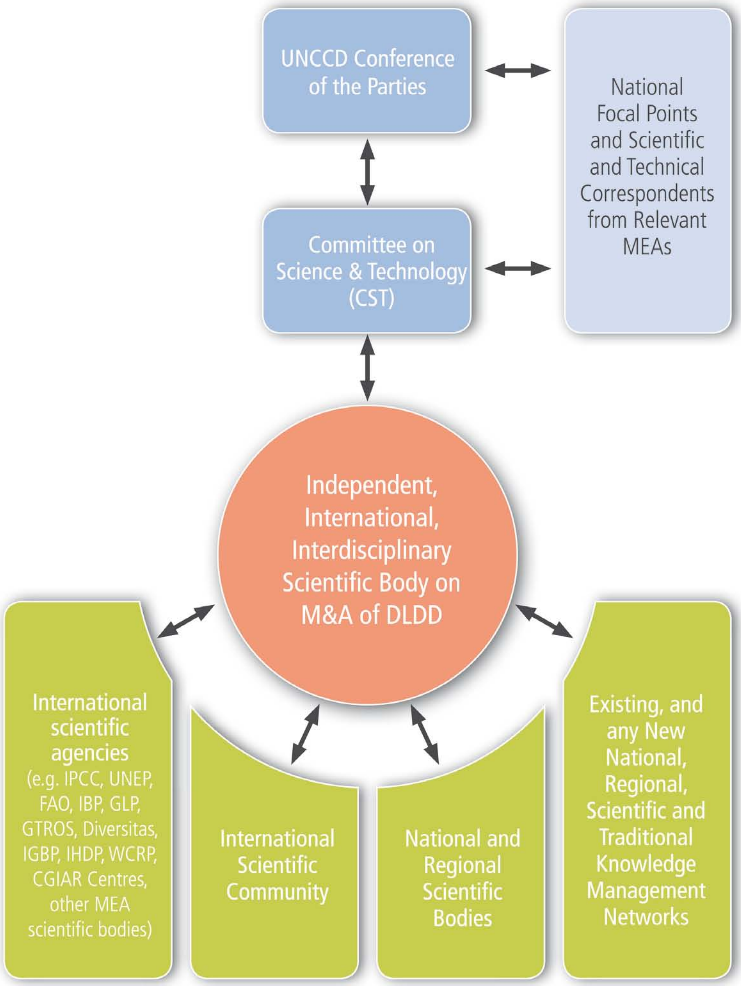
There are precedents in the UNCCD for establishing such a body. For example:

- in Article 17: "The Parties undertake, according to their respective capabilities, to promote technical and scientific cooperation in the fields of combating desertification and mitigating the effects of drought through appropriate national, subregional, regional and international institutions."
- in Article 25: "Networking of institutions, agencies and bodies. The Committee on Science and Technology shall, under the supervision of the Conference of the Parties, make provision for the undertaking of a survey and evaluation of the relevant existing networks, institutions, agencies and bodies willing to become units of a network. Such a network shall support the implementation of the Convention."

There have also been calls for such a body at other meetings, including at previous UNCCD meetings, the UNEP Governing Council, the EC and the United Nations University.

As envisioned, the independent, international, interdisciplinary scientific body on DLDD and sustainable land management would work hand in hand with existing networks at the international, regional, national and local levels. As you can see in Figure 11, scientific guidance (in lime green) comes from these different levels and the through the possible establishment of national and regional scientific panels, along with the international scientific community. These national and regional panels would benefit from input and collaboration with existing and new national, regional scientific and traditional knowledge management networks. Scientific guidance through the new body could respond to requests for advice from national focal points and scientific and technical correspondents from relevant multilateral environmental agreements, as well as from the CST and the UNCCD COP. This system could work to provide science, capacity building and knowledge management challenges at the international level.

Figure 11: Establishment of an independent, international, interdisciplinary scientific body



Working Group 3, keynote presentation 4
Economic aspects and social drivers of land degradation

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Credit: C. Martius

Stefan Sperlich

Introduction: Why economics?

First of all, some may ask: why and to what extend should we care about economics in the context of DLDD? As a matter of fact, mostly, when 'economics' is mentioned in this context, people think either of costs and other economic consequences land degradation can have, or of the costs combating land degradation will cause (including monitoring and rehabilitation). This typically goes along with the legitimate hope that economists will not only offer a comprehensive cost accounting but also provide a funding scheme.

However, while this is certainly an important issue, one should start with trying to better understand what the social or economic drivers of land degradation are. We may even start with the simple statement that land degradation could also be considered as the outcome of economic activity, though it is certainly not the objective of this activity. It is not difficult to interpret land degradation and desertification – at least in most cases – as dramatic resource mismanagement. The resource mismanagement may be caused by structural market failures, pushed by external social drivers like population pressure and poverty, or the result of short-term profit strategies. We believe that this point of view should be emphasized more than the cost and funding issue, as it can lead to the prevention of land degradation and is therefore economically sustainable.

Nonetheless, at least as important and challenging as this first aspect is the request for a cost–benefit analysis. Cost–benefit because we have costs of land degradation on the one hand but also the significant pay-offs of sustainable land management. Indeed, sustainable land management can raise incomes, combat poverty, extend productive use of land into the future – and therefore is directly related to food security – and reduce vulnerability to climatic fluctuations.

The economic framework

In the following section we will look at desertification as predominantly the outcome of resource management failure in arid, semi-arid and dry sub-humid areas. It should be noted that the presented economic approach concentrates on *ex-ante* solutions. This is only for the sake of brevity and not because we discount all the other aspects and approaches.

a) DLDD as an externality

As already said, DLDD is a result of production activity but also a negative factor in it, though with a serious time lag. Apart from the fact that it is an unwanted by-product of production, we should not forget that DLDD is not a necessary output; it is rather the consequence of inappropriate means of producing, as for example in the overuse of resources and fertilizers. Moreover, for production processes per se, DLDD is external. We observe prodigal exploitation for many reasons: due to collective operation when land and/or water are public property; due to the lack of prices and markets for DLDD-sensitive goods; sometimes due to population pressure, small plots and poverty; and certainly in some cases due to climate change (while, admittedly this is a baneful synergetic process).

In such cases, economic theory proposes the 'internalizing' of the effects and factors related to DLDD. This can be done, for example, by attributing clear property rights and by establishing regulatory instruments like taxes and subsidies or norms and laws. It should be emphasized that these instruments are not thought to be new sources of capital to finance the requested projects (monitoring, assessment, rehabilitation etc), but rather to be a way to fix the markets.

In order to find appropriate means, there is still a tremendous need to study causalities and adaptive solutions. We speak here of adaptive solutions to highlight that one has to account for different constraints, like low income, lack of knowledge, corruption or other political and institutional failures. Apart from these, there are serious space- and time-scale problems in measurement, modeling and valuation.

b) The economic valuation of the environment

Not surprisingly, there exist different valuation strategies and we briefly discuss some of them here. The *direct method* determines the physical effects of variations in the environment on economic activities and measures the monetary value of the damaged ecological function. The *indirect method* assigns a monetary value to the physical damage caused by environmental degradation; it is not based on the behavior of economic agents but assumes that environmental quality is a production factor and thus affects the prices of products.

Furthermore, there exist techniques for valuating erosion by agro-ecological models. For example, the universal soil loss equation takes into account the effects of rainfall and wind on soil erosion, and the Millennium Ecosystem Assessment calculates environmental values in terms of services provided by ecosystems. Spatial approaches are based on dividing the 'rural space', ie the land, according to its main economic uses. For any of these approaches, again note the problems of scale.

c) Costs of land degradation and loss of ecosystem services

Although research publications on the cost of DLDD are numerous, due to insufficient data any cost-benefit analysis is based on coarse assumptions, and consequently the available analyses vary considerably. Apart from the data problem there are other obvious but important limitations. Internal limitations are the time- and space-scale problems already discussed. In fact, the final value always depends upon the period of time chosen as a reference, as well as on the size (or shape) of the area under consideration. External limitations are, for example, the applied reference price for the considered good (or activity) but also the possibility of considering different activities in the same dry area (eg according to the seasons).

We should be aware of the fact that the values assigned to the costs of land degradation and the loss of ecosystem services are almost always greatly underestimated. This is not only due to the difficulties of valuation discussed above, but also due to the suppression of indirect costs or effects. Examples include the silting up of dams and subsequent losses of water and electricity, and disturbances for fishing, shipping and tourism. Other examples are the impact of dust clouds on human health. Or, simply take the losses of carbon and biodiversity, not forgetting the often dramatic consequences of poverty, hunger, violent conflicts and finally migration.

Policy mechanisms

As indicated above, the aim should not be to find sources of capital for financing new projects but rather the need for appropriate modeling to create an economic environment that promotes DLDD prevention and sustainable land management. Recall first that it is quite easy to show the market failure of under-pricing scarce natural resources, for example using the utility approach. Second, economic instruments like tradable certificates, resource pricing or fiscal mechanisms should try to reinstall full-cost pricing to yield a more efficient resource allocation.

i) Cross-scale and related mechanisms

We have to understand that excessive resource depletion and environmental degradation arise from distorted price signals, which result from the absence or thinness of markets for resource and environmental assets. This is partly due to the lack of well-defined, secure and transferable property rights over resources. In other words, with exclusive and secure property rights, resource depletion is internal to the owners; see the discussion on 'internalizing'.

Among market-based approaches, payment for environmental services represents an instrument for direct conservation. The principle idea here is that producers of environmental services receive compensation (monetary, technological etc) from beneficiaries of the ecosystem services. Today, these kinds of payments cover watershed protection, biodiversity conservation, landscape aesthetics and carbon sequestration. International payments for carbon sequestration represent a most developed form of an international payment for environmental services. Typically, wealthy beneficiaries would pay, poor countries would protect and all would benefit (equity). Other successful instruments are selling and controlling permits for land and/or water use referring to aggregated levels.

ii) State mechanisms and international cooperation

Once again, we recall that the aim is the 'internalization' of land degradation to the economic activity (or simply production). This may be organized by taxes and subsidies (eg environmental fiscal reform) or by legal enforcement via damage payments, to mention a few. Certainly, we should not only count on fiscal mechanisms and legal liability but also on moral suasion. A good example of international instruments is the so-called debt-for-nature swap.

iii) Private mechanisms and self-regulation

We should not ignore that apart from the above-mentioned moral suasion, we can help producers to realize that sustainable resource utilization has positive benefits for them and/or their children. This only holds true if property rights are clarified. Often producers are forced by circumstances to harvest environmental resources at a higher than sustainable rate. As a consequence, to reduce the pressure on resources, we have to be aware of the simple fact that alternative means of earning a living must be available. For obvious reasons, this may also have to happen outside agriculture and related fields.

If we do not want to leave the state alone with this problem – we are discussing 'private' mechanisms in this paragraph – then there is a need to provide a functioning credit and grant scheme for promoting local livelihoods. Note that for this to be successful we also need secure property rights. The definite success depends on simultaneous capacity building.

Valuation of action to combat DLDD and promote international investments

It is necessary to measure the success of action (for donors, non-governmental organizations etc) and to subsequently select the most efficient techniques for specific contexts. Obviously, these have to be linked with the monitoring and assessment and knowledge management issues.

Typical problems of the valuation are that rates are high when DLDD is moderate, weak for prevention, and very weak for degraded land. Also, most of the development projects focus on the return of action plans, which is often difficult to predict. Recall the problems of short-term versus long-term and time lags. Lastly, recall that the calculation of the rate of return of such projects should take into account the indirect benefits related to the reduction or absence of DLDD (see discussion above).

Acknowledgements

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The Contact Group advised the UNCCD Committee on Science and Technology and the Conference of Parties on ways to make best use of the Conference recommendations.

Recommendations of the UNCCD First Scientific Conference (including Rationales)

1. DLDD as defined by the UNCCD results from dynamic, interconnected, human–environment interactions in land systems, where land includes water, soil, vegetation and humans – requiring a rigorous scientific framework for monitoring and assessment, which has been lacking up to now.

The text of the UNCCD places humans "at the center of concerns to combat desertification and mitigate the effects of drought". It notes that DLDD "is caused by complex interactions among physical, biological, political, social, cultural and economic factors" and is interrelated with "social problems such as poverty, poor health and nutrition, lack of food insecurity" and other factors. The Strategy of the UNCCD reconfirms this mission orientation as reflected in its science-related Strategic Objectives (1–3) and their associated expected impacts.

To meet UNCCD expectations, therefore, monitoring and assessment of DLDD must effectively address complex human–environment interactions. This is a formidable challenge. The analysis of complex systems lies at the frontier of earth systems science and global change science.

Monitoring and assessment procedures have so far been largely empirical, focused on the symptoms of DLDD rather than the underlying drivers and processes. Only since the late 1990s have interactions between human and climatic drivers, as well as the temporal and spatial scales of the phenomenon, been integrated into these concepts and frameworks to build on the interrelationships within coupled human–environment systems that cause DLDD.

Innovative assessment and monitoring concepts are required to translate these frameworks into concrete action. Building on recent advances in monitoring the state (condition) of land surfaces and its temporal trends (eg in the analysis of indicators of ecosystem health, in social, economic, policy and knowledge dynamics, and in restoration and preservation methods), advanced integration concepts and tools are needed to develop efficient adaptation and mitigation strategies.

Leading conceptual frameworks for analyzing complex DLDD information proposed in recent years include the driving forces-pressures-state-impacts-response initiated by the OECD and the persistent reduction in the capacity of ecosystems to supply services (Millennium Ecosystem Assessment 2005). The recent DDP (Reynolds et al. 2007) attempts to synthesize this conceptual progress into an integrated framework centered on the coupling between human and environment systems as they co-adapt to each other in a dynamic fashion in drylands.

Following Reynolds et al. (2007), research and practice in these fields have increasingly converged into a set of general lessons concerning the condition and dynamics of human–environment systems that can form conceptual guidelines for more effective monitoring and assessment:

- Both researchers and practitioners need to adopt an integrated approach; ecological and social issues are fundamentally interwoven, as are the options for livelihood support and ecological management.
- There needs to be heightened awareness of slowly evolving conditions; short-term measures tend to be superficial and neither resolve persistent problems nor deal with continual change.
- Non-linear processes need to be recognized; dryland systems are often not in equilibrium, have multiple thresholds, and thus exhibit multiple ecological and social states.
- Cross-scale interactions must be anticipated; problems and solutions at one scale influence, and are influenced by, those at other scales.
- A much greater value must be placed on local environmental knowledge.

This progress in framing complexity in addressable ways is helping guide the development of holistic yet scientifically-sound monitoring and assessment strategies and methods. While much more progress is needed, a number of tools and methods are already available which can significantly enrich the insights obtained from knowledge-driven monitoring and assessment.

The foregoing discussion leads to the conclusion that DLDD cannot be measured in terms of a single numerical value, nor by an index value calculated from mathematical combinations of qualitatively different parameters (eg soil erosion, human well-being or ecosystem resilience) because these combine very different types of data without reflecting the context-specificity and dynamism of each component.

2. To be sufficiently realistic and insightful in light of this complexity, monitoring and assessment must make use of a wide range of analytical methodologies, and distil the lessons into forms useful for decision makers through integrated assessment modeling.

People-centered monitoring and assessment of DLDD must deal with the reality that different stakeholders have different perceptions of land degradation. From an environmentalist perspective, the clearance of land for agriculture may represent degradation, whereas from a land user's perspective it may represent an improvement, because it changes the land in ways that yield more immediately valuable agro-ecosystem services. Assessment of the biophysical condition of land must be complemented, therefore, by assessment of what that condition means to stakeholders.

Simple indicators reveal only a small part of the complex DLDD picture, and do not reflect the dynamic nature of human–environment systems' co-adaptation and stakeholders' perception of land condition. To reduce the costs of data collection, institutions sometimes seek indicators from readily available non-DLDD databases (such as water, environment, agriculture, health). But a consequence is that these only partially and indirectly relate to DLDD.

Due to these limitations, monitoring and assessment based on a minimum indicator set may be only a starting point for assessing the broad impacts of implementing the UNCCD. Rather than just using fixed indicator sets, the UNCCD community should make progressively greater use of the full range of analytical methods available, within the framework of a carefully planned, holistic, multi-scale monitoring and assessment regime. This will enable the more flexible and insightful use of indicators attuned to the aims of the UNCCD.

Proven techniques already exist within the methodological areas of field research and case studies, modeling, mapping, diagnostics, scenario analysis, participatory analysis, cost-benefit analysis, trend analysis, development pathway analysis, knowledge systems analysis, stakeholder analysis, sustainability analysis and many others. The application of multiple knowledge sources also helps to triangulate the investigation in order to more fully and accurately characterize the entity that is being monitored and assessed.

Given the complexity of DLDD, the use of expert knowledge (including that of land users) will remain a valuable component of monitoring and assessment. Expert knowledge can integrate and compare complex information in ways that lie beyond the capabilities of analytical instruments, but it needs to be addressed using commonly agreed criteria and judgment procedures.

Furthermore, expert knowledge needs to be incorporated into analytical methods. Several systematic methods are available and experience in their use has been gained in the field of DLDD. When stakeholders and decision makers with diverse backgrounds participate in the conceptual stage of formulating a model, this tends to reduce ambiguities and logical inconsistencies and to focus attention on the main processes and state variables most crucial to the DLDD problem at hand.

Through the analytical methods listed above, a wide range of complementary information can be generated, which then needs to be integrated. Integrated assessment models serve this purpose, particularly linking the human and biophysical dimensions of DLDD in ways that generate useful knowledge for decision makers. Integrated assessment models improve the quality of discussions in support of decision-making because they allow scientific exploration of the complex interactions that occur in human–environment systems. They reveal information such as policy and decision trade-offs and consequences, stakeholder negotiation outcomes, risks, uncertainties and vulnerabilities, and they enable the ranking of choices among competing priorities.

Practical examples of the first steps towards implementing these concepts at larger, quasi-operational scales are initiatives such as WOCAT, LADA and the Australian Collaborative Rangeland Information System (ACRIS), which are described further in item 3 below.

3. Public land use and land management decisions are mainly taken at national and sub-national levels, and so a UNCCD global monitoring and assessment strategy should be designed to be compatible and synergistic with these levels.

Decision makers at all scale levels need to know, but in differing degrees of detail and focus, the following:

- the nature (for instance erosion, productivity decline or bush encroachment), spatial distribution, severity and extent of DLDD and the trends over time; this requires a baseline against which to monitor change, and periodic re-observation and assessment to determine the direction and rate of change
- the causes of DLDD; both social and environmental causes need to be considered, as do influences arising from activity at other levels
- the risk of DLDD occurring in areas currently not affected
- actions that can counter DLDD and their outcomes and impacts
- the benefits/costs (both monetary and non-monetary) of doing nothing versus those of preventing or correcting DLDD problems.

Since policy and institutional decision-making authority is usually concentrated at national and sub-national levels in most areas of the world, DLDD monitoring and assessment information particularly needs to provide the degree of detail needed by decision makers at these levels.

Much of the global-level DLDD information desired by the UNCCD can be built from careful analysis of such national and sub-national information, as long as compatible protocols and standards are used. Efforts are needed, therefore, to ensure compatible, useful and scientifically valid standards and protocols for monitoring and assessment across national and sub-national levels. This harmonization is a contribution that can be made by the scientific partners to the UNCCD, with UNCCD endorsement.

The DDP conceptual framework described earlier asserts that "coupled human–environment systems are hierarchical, nested, and networked across multiple scales". While bearing level-specific characteristics, social, economic and ecological systems in drylands are also linked through social networks, communications and infrastructures to other scalar domains (Stafford-Smith et al. 2009). Cross-scale linkages between stakeholders require particular attention, not only at the institutional level but also for data and information transfer across other scale dimensions.

Building on these social implications, this DDP principle recognizes that the issue of scale is crucial for monitoring and assessment strategy. Key ecosystem services offer a consistent set of themes across scale, eventually emphasized differently at the various scales, for nesting key variables in order to up-scale data meaningfully. Based on scoping local knowledge and integrated assessment models, conceptualized knowledge on the particular DLDD situations and human–environment processes for each scale and location can determine the most important variables to monitor.

These variables comprise internal controlling drivers, such as water availability and stocking rates at household or communal level – at this scale these are often perceived as 'fast' changing – and external drivers resulting from processes on a wider scale, such as landscape function, land use and climate change at national and global scales; these are usually perceived as 'slow' at the household level. Nesting slow variables in consistent themes permits some data and information to be scaled-up in a diagnostic and coherent way that relates to persistent changes in ecosystem function. This architecture should best be designed using insights provided by the syndrome approach.

At the global level Geist and Lambin (2004) surveyed 132 desertification case studies and identified typical repeating causal patterns, resolving into four major proximate causes explained by six major underlying drivers. In a similar, albeit broader, concept, Schellnhuber et al. (1997) hypothesized that a mere 16 syndromes (bundles of interactive processes and symptoms) might explain all major global environmental change phenomena, including those relating to DLDD.

The effect of cross-scale interactions on dryland systems down to the local level, and the need to focus on appropriate slow variables to determine the state of co-evolutionary systems, have been described in several studies in Australia, China and Niger (Stafford-Smith et al. 2009). Numerous studies of smallholder farming systems in Africa have observed that the great diversity of soil conditions can often be resolved for purposes of analysis into a small number of land states and trends, for example resulting from patterns of transferring scarce nutrients from outer fields to those near the household in order to increase the yields of the most important food crops – although the story does not end there. Influences at other scales, such as global trade and development policies, affect decision-making for such small-scale farmers (Scoones 2001).

It is this conceptual description of scalar influences on human–environment processes, hierarchically linked through a consistent set of themes, which provides strategies for designing monitoring needs and for scaling the assessment information. Such strategies can greatly increase the power and cost-effectiveness of monitoring and assessment activities. Rather than collecting large, comprehensive sets of indicator data in all locations, including many variables that are relevant only to a subset of locations, monitoring and assessment teams can focus on the key nested variables, patterns and syndromes that can be meaningfully linked at all levels.

A number of recent, pilot-level monitoring initiatives are currently establishing multi-scale systems for knowledge gathering, monitoring and analysis. Multi-temporal analysis of remote sensing data is increasingly integrated with interpretation schemes based on conceptual models of human–environment systems (Hill et al. 2008). For example, the ARIDnet network is exploring the application of human–environment system principles in several Latin American countries. The challenge of linking local approaches to those at national and international levels is addressed by Reed et al. (2008).

WOCAT has developed methods and tools for documenting and evaluating sustainable land management technologies and approaches at local levels and to assess their dissemination to sub-national or national levels. Recently, these case studies have been incorporated into a participatory process of identifying and selecting best-suited implementation measures. The WOCAT mapping method has been further developed and tested together with the LADA project coordinated by the FAO. Similarly, Australia has launched ACRIS which addresses human–environment interactions in the assessment of national rangeland states and trends.

These frontline-applied research initiatives provide excellent building blocks, which can be blended with emerging advances on integrated assessment models and novel knowledge management techniques.

4. Sustainable land management is imperative to address the UNCCD's core mission to combat desertification; therefore sustainable land management monitoring and assessment should be fully integrated into DLDD monitoring and assessment.

Historically, the emphasis in monitoring and assessment has been placed on delineating the nature and extent of the problem of DLDD. Noting that the title of the UNCCD expresses a mission to *combat* desertification, it would also be appropriate and desirable to place a strong emphasis on the monitoring and assessment of solutions. LADA, for example, has drawn heavily on WOCAT and DESIRE methodologies to broaden its monitoring and assessment regime to include sustainable land management solutions, as mentioned in item 3 above.

Information on the progress of solutions to DLDD will be valuable to those who are investing in such solutions or are considering doing so, and could spark greater support for the UNCCD. It will also enable them to identify corrective actions, if needed, to improve progress.

Sustainable land management solutions, for example, form the core strategy of the Land Degradation Focal Area of the GEF. Since its inception, the GEF has invested US$ 792 million in projects and programs supporting sustainable land management to combat DLDD and deforestation. The GEF is developing monitoring and assessment procedures to track sustainable land management gains and benefits resulting from these investments (such as the KM:Land Project).

A working definition of sustainable land management suited to the UNCCD human–environment interactions perspective might be 'land managed in such a way as to maintain or improve ecosystem services for human well-being, as negotiated by all stakeholders'. Observations of land cover, land use and land management systems provide entry points for monitoring and assessing the sustainability of land management, that is, determining whether soil, water, nutrients, vegetation and other sustainability-determining assets are being managed in ways likely to support their continued viability.

Rapidly advancing geospatial methodologies hold much promise for linking a wide range of data, socio-economic as well as biophysical, across scales that provide insights into sustainable land management trends. The short-term nature of most project funding hampers the monitoring and assessment of long-term phenomena such as sustainability, but principles and practices known to contribute to sustainability can be useful proxies (practice-based approaches), such as maintaining land cover, controlling surface water flows, increasing biodiversity and many others.

The judgments of stakeholders, however, may differ on the preferred configuration and magnitude of the different assets and services that ecosystems produce; for example, some may benefit more from farmland, others from rangelands, and still others from wild lands. Each land use system can be managed sustainably or unsustainably within its own context; thus contexts must be considered in the monitoring and assessment of sustainable land management. Participatory monitoring and assessment involving a representative range of stakeholders is therefore required.

Socio-economic and policy dynamics strongly influence sustainable land management adoption and impacts. Policy changes can quickly drive systems towards either more or less sustainable land states. Factors such as land tenure, labor, access to inputs and markets, among others, must also be monitored and assessed.

Water is a major constraint for sustainable land management in drylands, and sustainable land management can improve water management. The potential for irrigation development is hampered by many issues (cost, secondary impacts etc). Distant mountain ranges act as 'water towers' supplying the drylands, along with other watershed landforms (basins, catchments etc) but climate change and deforestation are degrading these resources. Sustainable land management monitoring and assessment must take these dynamics into account.

Local knowledge is a rich source of ingenious water-harvesting solutions. Adaptation of agricultural species and management practices is often the only feasible solution, but it is only a partial one. Drought can erase hard-won development gains and make land users risk-averse, inhibiting sustainable land management investment. Sustainable land management monitoring and assessment should be designed to inform early warning systems for drought and include parameters related to drought resilience. Social safety nets and alternative livelihoods have an important role to play in reducing drought vulnerability.

Sustainable land management requires a balancing of system inputs and outputs, such as nutrients needed for vegetative growth. Purchased inputs can replace those exported from the farm but this strategy creates concern in a long-term global perspective, and so this issue should be monitored and assessed.

Economic forces may push purchased inputs beyond the reach of many dryland poor people; prices of key fertilizers are likely to climb steeply in the coming decades due to the high cost of energy used in nitrogen production and diminishing global supplies of high-quality phosphorus. Strongly negative continental nutrient balances have been estimated for sub-Saharan Africa. Nutrient losses also create pollution problems in downstream ecosystems.

Nutrient monitoring and assessment can be costly, however, and is plagued by spatial variability. Infrared spectroscopy is an important advance; providing rapid, low-cost measurement of several nutrients, it is now being applied in continental-scale soil health surveillance through the Africa Soil Information Service. Strong interactions exist among soils, water, nutrients and vegetation; these should be monitored and assessed through systems modeling to reveal ways to increase nutrient recycling for more sustainable land management.

Low soil carbon content is a widespread constraint in drylands, limiting productivity through a number of biophysical mechanisms. Models available today can provide valuable indications of carbon states, trends and impacts, but continued improvements are needed to calibrate them for different dryland settings. Sustainable land management practices can increase soil carbon content, but scarcities of nutrients and water, as well as economic drivers, tend to constrain the achievement of this potential.

Additions of carbon to dryland soils in the form of biochar (charcoal created by the pyrolysis of biomass) may have potential for improving productivity in sustainable ways. This hypothesis urgently needs further testing to resolve uncertainties. Additions of biochar could simultaneously combat climate change and generate renewable energy. Its economical viability needs to be considered and precautions taken to avoid its becoming a driver of deforestation. Biochar can be easily monitored, since known quantities would be added to known areas of land.

5. The monitoring and assessment of DLDD and sustainable land management should include the collection of information relating them to climate change and biodiversity, and to other land-related issues that are the focus of multilateral environmental agreements.

The global environment is deteriorating in a number of interrelated ways that have triggered international action through multilateral environmental agreements. While the UNCCD brings focus to the issues of DLDD and sustainable land management, land dynamics also impact the concerns of its sister Rio Summit multilateral environmental agreements, the UNFCCC and the CBD. Land issues also impacted the topical areas of the Ramsar Convention on Wetlands (established in 1971), the World Heritage Convention (1972) and the Convention on Migratory Species (1979).

The interconnections between DLDD, climate change and biodiversity loss were highlighted by the Millennium Ecosystem Assessment Desertification Synthesis 2005. The Millennium Ecosystem Assessment notes that drylands, which cover a third of the Earth's land surface, hold more than one-quarter of the world's organic carbon stores and that DLDD causes the release of an estimated 300 million tons of carbon into the atmosphere annually. The loss of vegetation due to DLDD exposes the soil to erosion and disables the recycling of nutrients, further degrading biomass productivity. These effects also degrade habitats and adaptation conditions needed to support diverse plant and animal species. Less vegetation results in increased surface albedo and dust, which may affect the climate at local and global scales. Dust can also affect other ecosystems and human health.

These interconnections also imply that strong positive synergies are achievable from actions that counteract DLDD, such as sustainable land management. For example, increases in carbon sequestered in soil also increase crop yields and therefore food supplies and food security, while also increasing land cover and reducing soil erosion. Thus, sustainable land management contributes to both adaptation and mitigation strategies against climate change.

The future adoption of carbon-enhancing and sequestering sustainable land management practices is likely to be strongly driven by economic incentives such as the carbon credit policies currently under global discussion. These social forces should also be monitored and assessed in order to inform DLDD decision-making so that effective carbon policies are devised and implemented.

Natural biodiversity supports crucial ecosystem services that counter DLDD and improve human well-being, such as nutrient cycling, erosion control, water flow moderation and purification, pollination, pest control, energy (fuelwood), structural materials, medicines, herbs, foods, ecotourism, and aesthetic value, among others. Agricultural biodiversity particularly supports food and animal feed supplies, livelihoods and income, pest and disease management, and the sustainability of land use systems. Wild species relating to cultivated crops serve as a source of valuable genetic variation for plant breeding. The loss of habitat and migratory pathways and services for fauna degrades ecotourism value. *In situ* and gene bank strategies are complementary ways to preserve these assets and should be supported by monitoring and assessment information.

The clearance of land for agriculture can be considered as a DLDD dynamic that usually results in a large reduction in biodiversity. Agricultural development strategies need to be designed in ways that minimize that damage, for example via the 'eco-agriculture' concept. Local knowledge can often reveal the value of biodiversity components that are not familiar to commercial market channels. Even when value is uncertain, the extinction of biodiversity components would be irreversible and so a precautionary approach should be taken in adherence to Principle 15 of the Rio Earth Summit (United Nations Conference on Environment and Development 1992) and other international agreements.

Monitoring and assessment data are essential for biodiversity conservation. The 2010 Biodiversity Indicators Partnership, for example, is producing global-scale, DLDD-relevant indicators aiming to reduce the rate of biodiversity loss significantly, many of which are also applicable at the regional, national and sub-national scales.

Climate change and human activities will alter habitats resulting in shifts in species and in gene frequencies for adaptive traits (such as heat, pest and disease resistance). Some changes may be too rapid for evolutionary adaptation, causing thresholds to be crossed that can destabilize ecosystems in disastrous ways, such as by causing massive pest/disease epidemics, fires and shifts in dominant species. Such disasters can debilitate carbon sequestration, nutrient recycling and other ecosystem functions, generating feedback loops that further aggravate climate change and DLDD. An example that has degraded many dryland areas is the encroachment of woody shrubs into rangelands. Monitoring and assessment tools are needed that can foresee such risks and thresholds to provide early warnings for decision makers.

6. To aid decision makers in setting priorities, monitoring and assessment should collect information on the economic, social and environmental costs of DLDD, and the benefits of sustainable land management. The potential role of economic modeling should be explored to develop policy mechanisms that can facilitate sustainable land management decisions.

National decision makers are flooded with urgent demands for action on a wide range of issues, and must make choices among them. A major factor influencing such decisions is the prospective return on investment, as demonstrated by the impressive impacts of the Stern Review on the Economics of Climate Change and the highly anticipated impacts of the Economics of Ecosystems and Biodiversity on decision-making by governments. Long-term benefits need to be considered to ensure sustainability, enable wise land use planning and reveal the true costs of short-term land exploitation and 'land grabs'.

Due to insufficient data, DLDD-related cost-benefit analyses are few and based on coarse assumptions. This shortcoming is unfortunate, because combating DLDD should in principle yield very significant returns on investment. The benefits and costs of monitoring and assessing itself (as advocated in item 1 above) should also be delineated, so that parties gain a clear rationale for engaging in this activity.

Sustainable land management interventions can transform DLDD losses into gains by raising incomes, reducing vulnerability to climatic fluctuations, and extending the productive use of land well into the future. Other means of combating desertification and sustaining livelihoods can also deliver important benefits (eg land rehabilitation, carbon sequestration, ecotourism and off-farm employment).

An accurate cost-benefit analysis must consider the value of environmental services, whether or not a mechanism exists for actual monetary payment for their use. Not all values (benefits or costs) are monetary; the land provides a range of ecosystem services that benefit humans in both tangible and intangible ways (such as culturally and spiritually).

Much research is under way globally to establish values of ecosystem assets, goods and services (and their loss, due to DLDD for example), including both monetary and non-monetary values. The valuation of biodiversity has made particular progress. The principles can be extended in a straightforward manner to other DLDD assets, goods and services.

Even when no fees are paid for ecosystem services, the revealed preferences of economic agents can be observed in order to estimate values. Such methods include public pricing, avoided-damage values, replacement/substitution costs, travel expenses to a site to gain ecosystem services, mitigation costs, hedonic pricing, contingent valuation (willingness to pay for a service), and local group evaluations, among others.

Where economic agents cannot be directly observed, indirect valuation is used. This approach assigns a monetary value to the damage caused by land degradation using dose-response and replacement cost methods. For example, the cost of fertilizer is a way of estimating the value of the loss of soil fertility that it replaces.

A cost-benefit analysis leads naturally to an examination of the potential for payment for environmental services. Candidate ecosystem services most frequently mentioned for potential payment for environmental services are watershed protection, biodiversity conservation, landscape aesthetics, and carbon sequestration. More than 400 payment for environmental services schemes are currently under operation in many countries under public–private partnerships (not only in drylands).

International payments for carbon sequestration linked to the proposed United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (UN-REDD Programme) mechanism under the UNFCCC could generate financial resources for dryland countries. The cancellation of debt by lending nations in exchange for the protection of ecosystems by developing countries (debt-for-nature swaps) and microcredit to stimulate sustainable livelihoods are related opportunities for financing efforts to combat DLDD.

7. Monitoring and assessment should capitalize on knowledge management to stimulate valuable synergies between different sources of expertise across different spatial and temporal scales and levels, social settings, institutions, scientific disciplines and development sectors.

The complexity of DLDD demands monitoring and assessment approaches that are richly based in knowledge. Since many diverse interests (people, governments and institutions) hold stakes in land issues, monitoring and assessment must utilize multiple knowledge sources at different scales. Knowledge management addresses access to, and the conservation and sharing of, knowledge.

Knowledge management requires an understanding of how people learn in different settings (institutional, cultural, social) and how they overcome barriers to that sharing and learning. A vast literature has developed on how learning occurs or fails to occur in various settings. Much is known about the role of social networks, communities of practice, knowledge brokering, and the role of intermediaries in the sharing of knowledge. Agent-based models have been developed which explain how knowledge flows (or becomes sequestered) within social networks depending on behavioral characteristics.

As societies develop, the erosion of local knowledge is an especially urgent concern, particularly with respect to land management. Attempts to conserve local knowledge in databases have led to disappointment; knowledge tends to be preserved, developed and shared only when it is used. In practice, much knowledge exchange takes place during knowledge generation itself, dissolving the boundaries between knowledge production, transfer and application.

Research in Namibia, for example, found that land users had a deeper understanding of the causes and effects of environmental change, and a richer set of indicators, compared to those monitored by the formal sector. In Australia, Aboriginal knowledge has repeatedly exposed the limitations of short-term ecological research paradigms. However, care must be taken to properly attribute intellectual property rights to local communities.

By hybridizing local and scientific knowledge, more effective monitoring and assessment can be achieved. In Namibia, indicators identified by local farmers based on their information needs are monitored by the famers themselves; experts from the formal sector help to analyze and interpret their data and work with them to identify options for dealing with rangeland problems. This approach is captured within a systematic framework for DLDD monitoring, assessment and remediation *[Editor's note: for example see Reed et al. paper in this Proceedings]*.

A variety of methods exist for evaluating, combining and integrating local and scientific knowledge. However, the use of these tools is often inhibited by institutional, cultural, scale, level, language and other boundaries that inhibit knowledge flows.

Boundary organizations have emerged in an attempt to straddle these barriers. For example, the global Drynet network acts as knowledge broker between organizations interested in dryland degradation and sustainable land management. In Namibia, the Forum for Integrated Resource Management fosters knowledge exchange between farmers and those who provide services to them. The EC's MEDRAP Concerted Action (2001–2004) promotes knowledge exchange between the UNCCD institutional community and the scientific research community in Greece, Italy, Portugal, Spain and Turkey. WOCAT (described earlier) performs a clearing-house function for sustainable land management approaches while at the same time serving as a network of experts and practitioners at the national, regional and international levels, facilitating expert knowledge exchanges through direct contacts.

The effective storage and dissemination of knowledge requires bodies that carry out knowledge clearing-house functions. The OSS launched an initiative in 2000 called Desertification Information Systems – Environmental Information (DIS-EISI). DIVERSITAS, an international program of biodiversity science, carries out such a role in the field of biodiversity as well as utilizing that knowledge to develop scientific plans for decision makers and to communicate policy implications to them.

The use of monitoring and assessment knowledge within the UNCCD and related bodies poses challenges. The implementation of obligations in multilateral environmental agreements by national governments has been constrained by limited financial and human resources. For example, although there is wide agreement on the need for more coherence in the implementation of the Rio multilateral environmental agreements, this has been difficult to put into practice.

Within the UN system, numerous organizations and specialized agencies work on different aspects of DLDD, including the FAO, the UNDP, the UNEP, the WMO, the WFP, UNESCO, the Committee on Sustainable Development, the United Nations Forum on Forests, and the General Assembly of the United Nations, as well as the donor agencies that support their work such as IFAD, the World Bank, GEF and the regional development banks. Knowledge sharing among these institutions needs to be improved. Similar improvements are needed in knowledge sharing between institutions at the national level.

The seventh Millennium Development Goal requires countries to integrate (mainstream) the principles of sustainable development into their policies and programmes – a knowledge flow gap confounded by many institutional obstacles. However the National Action Plans developed by many Parties to the UNCCD have yet to be mainstreamed in most cases. Tunisia is an exception; its efforts to combat desertification are now embedded in the country's social and economic development plans. Swaziland has also established its National Action Program within the National Development Strategy, the Swaziland Environment Action Plan and the Poverty Reduction Strategy and Action Plan as well as in other strategies.

8. Sharing of local and scientific knowledge, tools and methods will enhance monitoring and assessment and strengthen human and institutional capacities.

The overarching constraint reported by ministries, agencies, non-governmental organizations, scientists, research projects and others in developing countries, and identified by virtually all studies and reports on the implementation of multilateral environmental agreements, is a lack of institutional, financial and human capacity to address physical and human resources and skills requirements adequately. Capacity affects responses to, and the effectiveness of, monitoring and knowledge exchange, along with the ability to implement treaties effectively.

Knowledge management can help to overcome this constraint if barriers to knowledge sharing and knowledge management between local, national, regional and international levels are eased. Capacity building needs to be cross-sectoral to overcome past shortcomings in addressing the complexities of DLDD, including the need to incorporate actions into government agendas, analyses, frameworks and policies.

In addition, capacity building needs to foster greater collaboration and coordination of activities at regional, national and local levels. A prerequisite to such capacity building would involve strengthening national/regional academic curricula on dryland science for development, thus training the decision makers of tomorrow and supporting strong ties between research and policy communities on sustainable dryland development.

The monitoring and assessment process itself acts as a capacity building function, as diverse stakeholders share their expertise and knowledge about the conditions and trends of land. Knowledge from different scale levels, including local knowledge, brings new and enlightening perspectives to the other stakeholders. The integration of monitoring and assessing both the problem of DLDD and its solutions, as discussed earlier, provides a mechanism for not only building capacities but also for converting them into action to solve DLDD problems.

Capacities should be built in a way that strengthens existing institutions in affected countries, increasing acceptance of the continuing need for monitoring and assessment activity. For example, the BIOdiversity Monitoring Transect Analysis in Africa (BIOTA) project has trained local 'para-ecologists' to carry out degradation assessment and monitoring using knowledge-sharing methods that inform local management decisions; they become key knowledge sharers in their communities. LADA is strengthening monitoring and assessment agencies in major dryland zones on three continents by developing regional training centers within national institutions.

9. Coordination and dissemination of new knowledge and methodologies for integrated approaches to DLDD and sustainable land management require the establishment of an independent, international, interdisciplinary scientific advisory mechanism which would include (but not be limited to) monitoring and assessment, with clear channels for consideration of its advice in Convention decision-making.

The breadth of scientific studies on DLDD is rapidly expanding the knowledge resources and toolkits available to make fresh progress against this difficult problem. These emerging opportunities need to be identified, evaluated and utilized on a continuing basis in ways that best support the mission of the UNCCD.

The UNCCD has taken an important first step in this direction through the organization of its First Scientific Conference. However, conferences may not be the optimum vehicles for providing ongoing scientific advice, building scientific knowledge bases, and carrying out in-depth assessments and analyses. To provide the continuity, breadth and depth of support that the UNCCD mission requires, an ongoing, independent, scientifically credible mechanism is needed.

Such a mechanism should be policy-relevant but not policy-prescriptive. It should allow decision makers to be objectively informed about the likely consequences of different policy and implementation choices they might make.

The value of such a mechanism will depend on the degree to which it is perceived by the world as scientifically credible. To be credible, it must be transparently free of non-scientific influences, and thus managerially independent from the political process of the UNCCD. It must base its analyses on evidence that is verifiable, and subject its conclusions to widely recognized and scientific quality-control processes, such as peer review.

The mechanism should not conduct research itself, but draw on scientific knowledge and research findings that are continually emerging from the thousands of institutions and agencies worldwide that address different aspects of DLDD by tapping organized knowledge sources, where these exist (see item 11). It and should link this knowledge to capacity-building efforts (see item 8). The mechanism should also interact closely with national and regional science mechanisms that tackle DLDD (see Figure 11).

10. To propel principles into action, regular global DLDD and sustainable land management monitoring and assessment and early warning mechanisms should be organized and implemented, based on agreed standard protocols and open data access policies, to harmonize with other efforts worldwide and to minimize duplication of effort.

A mechanism is needed to implement the modern principles of monitoring and assessment for DLDD and sustainable land management described in this document. The UNCCD is the only one of the three Rio conventions that is not supported by a dedicated observation system; the UNFCCC benefits from the Global Climate Observing System and the CBD is supported by the Group on Earth Observations Biodiversity Observation Network system within the Global Earth Observation System of Systems. These systems facilitate the integration and interoperability of existing observation networks and enhance the credibility of the two conventions. The two systems were launched in response to the 2002 World Summit on Sustainable Development and given impetus by the G-8 group of leading industrialized nations.

In similar fashion, many DLDD scientists have urged the establishment of a global drylands observation system, or GDOS, to support the UNCCD. The GDOS concept would avoid replicating or duplicating existing monitoring and assessment systems. Instead, it would integrate and harmonize them, developing agreed standards and protocols that, as discussed above, are essential for an integrated global assessment.

A GDOS-type mechanism would synthesize and build on learning gained from pioneering DLDD and sustainable land management monitoring and assessment initiatives such as ACRIS, ARIDnet, Agro Hydro-Meteorology, the Asian Regional Network for Desertification Monitoring and Assessment (Asia-TPN1), BIOTA AFRICA, DESIRE, the Desertification Information System, to support National Action Programmes in the Mediterranean, the Global Assessment of Human-induced Soil Degradation, the Global Land Project, the Global Terrestrial Observation System, LADA, Long Term Ecological Monitoring Observatories Network/Sahel-Sahara Observatory and WOCAT, among others, as well as famine early warning systems that operate in many of the world's drylands, such as the Famine Early Warning System Network and the Global Information and Early Warning System. It would provide a platform for the continuing evolution of monitoring and assessment systems, for example, through the testing and implementation of emerging scientific concepts and techniques such as the DDP synthetic framework described in item 1.

11. The UNCCD community would benefit from a science networking mechanism so that the large yet dispersed body of DLDD and sustainable land management knowledge and expertise worldwide could be more effectively accessed, used and shared.

Due to its complex nature, DLDD research cuts across many scientific disciplines and intersects with other knowledge bases (such as development practitioners' and land users' knowledge). As a consequence, DLDD research and related knowledge is highly dispersed across thousands of universities, institutes, agencies and organizations around the world. For example, identifying and mobilizing this dispersed community in a short time frame was a major challenge in organizing the UNCCD First Scientific Conference.

This dispersion significantly impedes the flow of coherent scientific information to the UNCCD as well as synergies with other multilateral environmental agreements such as the CBD and UNFCCC. It also impedes the development of integrated scientific approaches and allows inefficiencies resulting from duplication and constrained knowledge flows.

To provide more comprehensive and responsive scientific input to the UNCCD, a networking and coordination mechanism for the global DLDD science community is needed. This would feed into the science advisory mechanism recommended in item 10, improving the efficiency and effectiveness of that advisory mechanism. In this way, the UNCCD could benefit from valuable services; for example, the mechanism could:

- determine the prevailing views of scientists worldwide on pressing DLDD questions
- mobilize scientific expertise to address specific questions and issues in more depth
- formulate widely supported scientific plans requiring global cooperation and donor backing
- provide a clearing house and platform for exchanging scientific knowledge and stimulating discussion about DLDD
- provide a mechanism for forming scientific partnerships to tackle high-priority DLDD research challenges
- provide a referral mechanism for scientific capacity building and mentoring opportunities with regard to DLDD.

DLDD scientists have begun organizing themselves through networks such as DNI and the Global Network of Dryland Research Institutes. This good start should be given more support and impetus. It should tap the Earth Science System Partnership framework that already contributes substantially to the knowledge bases of sister environmental conventions through the IPCC and the CBD. Other arrangements could also be envisioned. The UNCCD's endorsement of the need would provide support for the initiation of discussion by a range of scientific bodies on institutional formats for such a 'network of networks' mechanism.

Poster sessions

I. Africa

Traditional livelihoods and new coping strategies: monitoring land quality in pastoralist systems of Somaliland

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Abstract: The paper deals with the integration and disintegration of three major types of pastoral knowledge: traditional indicator setting, traditional forecasting and modern remote sensing. It analyzes the value of these systems to help pastoralist societies in decision-making in a changing environment, with a focus on slow variables and how well they are communicated among societies. Furthermore, the paper analyzes the main coping strategies of pastoralists and concludes that it is the expansion of migration patterns of livestock as well as financial contributions of urban and expatriate members of pastoral communities that are currently sustaining pastoral livelihoods. It recommends linking all management systems and various community members and governmental institutions for land rehabilitation and restoration initiatives to sustain pastoral livelihoods in future generations.

Keywords: pastoralists, local indicators, knowledge and information management, coping strategies

Introduction

The extreme vulnerability of pastoral and agro-pastoral communities in Somaliland to natural shocks and disasters as a result of desertification has been a widely known for the past several decades. Some of the problems these communities face are recurring droughts, limited public services, and vulnerability to epidemics, all of which contribute to weakened livelihoods. As a result, pastoral and agro-pastoral communities turned to the excessive exploitation of the scarce natural resources, leading to deforestation and desertification.

Body of work

Some of the major threats for sustainable livelihoods in the pastoral and agro-pastoral areas include: a) loss of livestock assets (animals); b) increased expenditures on grains and water purchases during droughts; c) reduced incomes mainly because of negligible milk sales, lack of saleable animals and reduced opportunities for alternative incomes; d) negative impacts on migration patterns due to the emergence of enclosures; e) ban of livestock trade by Arab countries; and f) switch of income generation from livestock marketing to charcoal production.

Proximate drivers are climate change, the almost total loss of grasses in the vegetation due to the introduction of cattle, political strife and the absence of functioning governmental structures on environment due to a preoccupation with security issues. Political isolation is also a key factor that prevents connection to international financial or environmental institutions such as environmental conventions, thereby hampering international knowledge exchange and the establishment of intervention measures for land rehabilitation by the international community.

Local indicators for desertification are based on a long-term observation of soil, vegetation and livestock and are very complex. Indicators such as camel milk production and the disappearance of grasses and certain species which indicate water storage capacities of soils are also meaningful under conditions of environmental change. Traditional forecasting systems, on the other hand, are based on astronomy, astrology and numerology, and have been valued to explain patterns that have not changed over millennia; these are becoming invalid with increasing environmental change, including predictions of changing angles between the position of sun and earth during the previous years.

To support environmental monitoring, a powerful modern remote sensing observation system has been established by the FAO, assessing all major indicators such as NDVI, land cover, soils etc. Although these tools are informed by local knowledge, up to now no system has been put in place to communicate the results back to communities. Nevertheless, communities show high adaptive capacities to cope with desertification – but not to restore and rehabilitate land, since droughts and desertification are perceived as godsent. But nevertheless declining natural capital is replaced by human and technological capital, especially through the flexible use of mobility, population and migration patterns.

Pastoral societies, traditionally split into two parts, one remaining with small agricultural plots and the other taking care of the herds, have had to expand their migration routes to much wider areas to cope with the emergence of enclosures and declining vegetation. They usually send scouts who are especially knowledgeable about land quality and climatic patterns to report on the land quality ahead. Other parts of the family, however, moved either to urban areas or abroad. Capital for pastoral communities back home is coming more and more through kinship relations from these urban and expatriate communities, which are the major economic backbone for current pastoralists. However, since it has come to be expected that a new generation will lose their close bonds to their familes, and although pastoral communities will always be based an a broad diversified network, it is recommended that communities reclaim their full sovereignty over their financial and natural resource management.

For the basis of analysis of relations between human well-being and decline of ecosystem services in pastoral societies, the Millennium Ecosystem framework was used, within a modified coupled human-environmental system approach similar to the DDP. Both the time cycles of soils, vegetation and human needs were explicitly considered, and a non-monetary as well as monetary-modified household economy approach based on Chayanov was used to explain the economic patterns.

Conclusions

Currently the three main knowledge systems, traditional indicators, traditional forecasting, remote sensing, are disintegrated and are only partly efficient to monitor and address desertification. Pastoral movements are hampered on the one hand by a number of factors including degradation of soils and vegetation and enclosures, leading to a general expansion of migration routes in total. The economic sustainability of pastoral systems is mainly based on kinship relations and remittances from urban areas and expatriates. This, however, is not fully understood and does not include interventions or investments in land rehabilitation. Also, due to the international isolation of the country, interventions by non-governmental organizations and international institutions are limited.

Recommendations for decision-making

- Identify local indicators for desertification and 'translate' them into scientific ones.
- 'Translate' scientific indicators into local ones.
- Work closely together with local scouts.
- Build networks with urban and expatriate communities who support their pastoral relatives.
- Build and strengthen capacities of the agricultural and environmental ministries.
- Connect environmental non-governmental organizations to international efforts of monitoring and combating desertification.
- Connect enviromental non-governmental organizations and community development committees through the Somalia Water and Land Information Management (SWALIM) initiative.
- Focus rehabilitation measures on water storage capacities of soils.

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Satellite remote sensing and spectral mixture analysis to monitor land cover degradation in a savanna region in Sudan

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Abstract: Remote sensing techniques have been applied in the study of desertification to monitor land cover degradation and characterize the dynamism of sand dunes. Two Landsat images, acquired in 1987 and 2008, were used to evaluate the development of desertification processes in Central North Kurdufan State (Sudan), part of the savanna region in the Sahel belt. Traditional methods to extract vegetation and soil information from remote sensing data in semi-arid areas, such as classification techniques and vegetation indices, were found to be inaccurate. In this work, spectral mixture analysis and multitemporal comparison techniques were therefore applied to emphasize vegetation loss, soil change and the growth of village areas in the study area.

Keywords: savanna, Sudan, remote sensing, land degradation monitoring, spectral mixture analysis

Introduction

The savanna region in Sudan is defined as a rangeland and rainfed croplands region. Degradation in vegetation cover by overgrazing and cutting of woody plants are the common desertification triggers (Mustafa 2007). Wind and water erosion are also accelerated by cropland preparation. Remote sensing is an effective technology that can be used to monitor and understand land degradations and the dynamism of sand dunes, as well as human activities at large scale. Spectral mixture analysis has also been proposed as an appropriate classification technique to be applied in dryland areas. The aim of this work was to apply the spectral mixture analysis classification method in order to calculate vegetation loss and soil change in the study area, as well as the effects of village area growth on desertification processes.

Body of work

Two Landsat images (Landsat5 TM and Landsat7 ETM+) of the study site (North Kurdufan State, Sudan), acquired on September 15th 1987 and October 18th 2008 respectively, were preprocessed and analyzed using spectral mixture analysis. The images were calibrated and converted from DNs to exo-atmospheric reflectance (Irish 1998). Image to image registration was conducted. Images had the same pixel size (30 m). Gaps in the Landsat 7 ETM+ scan-line corrector–off were filled using the localized linear histogram match method. Landsat 7 ETM+ SLC–off, a November 3rd 2008, image was used to fill the gaps as they were not overlapping.

The basic spectral mixture analysis equations are:

$$R_p(\lambda) = \sum_{i=1}^{n} f_i R_i(\lambda) + \varepsilon(\lambda)$$

where $R_p(\lambda)$ is the apparent surface reflectance of a pixel in an image; f_i is the weighting coefficient interpreted as fractions of the pixel made up of the endmember $i = 1, 2 \ldots n$; $R_i(\lambda)$ is the reflectance spectra of spectral endmembers in an n-endmember model; and $\varepsilon(\lambda)$ is the difference between the actual and modeled reflectance.

Four endmembers and spectral curves were identified using the method of Johnson et al. (1992): vegetation (V), non-photosynthetic materials (NPM), bright soil (BS) and dark soil (DS). V consisted of all types of natural vegetation (eg dense shrubs, grass) and cultivated crops. NPM identified villages, dormant trees and dead grass and shrubs. BS represented sand with low organic matter content. DS represented soil with higher water content or organic material. Four fraction endmembers images were derived for each satellite image and change detection was estimated.

Root mean square images for the spectral mixture analysis process showed an error range from 0% to 3% for the 1987 image and from 0% to 2.8% for the 2008 one. Assessment accuracy of spectral mixture analysis, using field survey data collected in September 2008, was estimated to be 87% for vegetation.

Multitemporal comparison during the rainy season showed that on average the decrease in vegetation cover was not significant over the 20 years. Higher rainfall in 2008 than in 1987 most likely promoted the seasonal growth of non-perennial vegetation (eg herbaceous species), partly masking the desertification phenomenon. However, significant changes in the spatial distribution were observed around the village areas (V had negative variations due to the cutting of woody plants) and where soil properties had changed (V had positive variations in areas where $\Delta DS > 0$ and negative where $\Delta BS < 0$). Soil property variations were partly caused by creeping sand dunes.

Conclusions

The meaning and value of remote sensing data were enhanced through skilled interpretation, in conjunction with conventionally mapped information and ground-collected data. Spectral mixture analysis has proved to be a powerful technique to monitor land cover degradation in the Savanna region of Sudan. The growth of village areas and sand dune creeping have caused damage to the fragile environment, reducing the vegetation fraction. However, the higher rainfall in 2008 partly masked the desertification phenomenon.

Recommendations for decision-making

Remote sensing has long been suggested as a time- and cost-efficient technology for monitoring dryland ecosystem environments. Remote sensing with skilled interpretation can be a very effective tool to establish a monitoring system providing data for: measuring long-term land cover and land use change; a forecasting system of desertification disaster; rehabilitation of desertified land; and distribution of projects for combating desertification.

More effort should be made to improve the classification of vegetation type in order to distinguish perennial from annual species and thus be able to monitor long-term vegetation degradation.

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Combating desertification and poverty through locally-governed land protection (*'Mise en defens'* strategy) in Senegal

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Abstract: Through the concept of protected areas, or 'Mise en defens', the rural communities agree on a number of regulations and procedures for the use of products from these areas. The concept aims at restoring the vegetation and socio-ecological equilibrium as well meeting needs of the population for forest products.

Keywords: land degradation, poverty, local convention, protected area, sustainable management

Introduction

The main goal of the technology of *'Mise en defens'* is the conservation of the forest ecosystem by entrusting rural populations with managing the forest and animal resources in their landscape. *Mise en defens* is a concept aimed at restoring the vegetation and socio-ecological equilibrium as well meeting needs of the population for forest products. Though this practice, rural communities agree on a number of regulations and procedures for the use of products from these areas.

Body of work

So far, 390 areas of *Mise en defens* covering 26,682 ha were established by communities. Results:

- In the protected area of Sambandé, which has been cultivated since 2000 and covers 1,500 ha the use of products generates revenues of US$3,000-4,000 per yard for women's groups in seven villages. The monetary value of what neighboring populations consume amounts to about US$5,000.
- In the district of Mbadakhoum revenues from the sale of forest products and honey by the women's group were estimated at US$2,000.
- Significant income from the exploitation of non-wood forest products (55% of the harvested products) is marketed.
- Strong contributions to food security (45% of harvested products) are observed.
- Rehabilitation of several plant species (improvement of biodiversity, development of medicinal plants and improving the health of populations) are observed.
- The reappearance of some wild animal species is also a very positive impact.
- The wood productivity of the area has increased, while there is regeneration of rare species and reappearance of lost ones such as *Nauclea latifolia*, *Grateova religiosa*, *Combretum lecardii*, *Ficus iteophilla*, *Grewia bicolor*, *Mitragyna inermis*, *Fagara xanthoxyloïdes*, and others.
- The protected areas of Sambandé and Mbadakhoun have contributed to the improvement of medicinal plant species, with about 87 and 60 species respectively.

Conclusions

Mise en defens contributed to combating desertification by restoring the vegetation and biodiversity through the development and implementation of local strategies for conservation, restoration and sustainable use of degraded agro-systems.

Recommendations for decision-making

- New strategies for the active involvement of local communities must be promoted for better sustainable management of natural resources in their own areas.
- Strengthening is needed of local communities' abilities and know-how in setting up a sustainable management and combating policy against land degradation.

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Sustainable agro-forestry system for re-claiming degraded land in the Federal Capital Territory near Abuja, Nigeria

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Abstract: The study was research carried out at the Federal Capital Territory near Abuja, the capital city of Nigeria. The essence of the research was to evaluate the impact of development and farming activities on the Federal Capital Territory environment and to identify the causes and extent of the degraded environments. The aim was to determine lasting solutions for the improvement of the environment by defining and arresting environmental problems that are likely to threaten the quality of fauna and floral lives or biotic organisms and abiotic components, and to identify adverse environmental degradation trends and maintain environmental stability and sanctity.

Keywords: Agroforestry, degraded environment, development impact assessment

Body of work

This research generated qualitative data that provide a graphical environmental analysis of the territory. The six Area Councils served as the research population framework. Communities in each of the Area Councils were stratified and sampling areas were randomly selected. These sampling areas were photographed and rapid appraisals were carried out to understand degradation causes and trends.

Combating desertification through biodiversity conservation in Cameroon

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Abstract: Desertification has adversely affected communities in Southwest Province, Cameroon through losses of groundwater, firewood and construction material along with increased flooding and extremes of temperature. Conservation of biodiversity in reserve forests and planting of economically valuable trees in farmlands are first steps in contributing to sustainable development and arresting desertification.

Keywords: climate change, adaptation, biodiversity, reserve forests, land degradation

Introduction

Desertification is simply land degradation from poor erosional practices, overgrazing, over-tilling, bush fires and other agricultural practices. When forests and their biodiversity are poorly managed, it is often because environmental laws and agreements have not adequately been implemented and enforced due to many factors, eg lack of resources, lack of capacity, lack of political will, cultural and religious barriers, inaccessibility and poverty.

The consequences of desertification are devastating, and the effects of climate change are especially fatal: floods, drought, storms and increased temperatures render most vulnerable poor families helpless. Water tables become depleted, drying off drinking water sources in village communities, forcing villagers – often women and children – to walk up to 5 km into the forests for drinking water, increasing child labor. Many marsh lands have dried up and certain native plants such as rafia, bamboo, rattan and cane that have been used for centuries for construction of houses have disappeared, making life miserable to many residents who cannot afford to put up a structure due to lack of finances.

During heavy storms, rivers overflow their banks and flooding causes severe damage to communities and the farmland, increasing hunger and the spread of diseases from open sewage and contaminated water. Temperatures have become volatile, causing harm to animals and crops, leading to poor agricultural yields and increasing hunger and poverty.

Consequently, the only way out is adaptation and the mainstreaming of best practices, sustainable use of biodiversity and the fair and equitable sharing of benefits from biodiversity, discovery of new potential sources of food and methods of storage, and implementation and enforcement of the various environmental agreements and laws.

Poverty and sustainable development in cocoa-producing communities

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Abstract: Cocoa cultivation has proven to be one of the best crops for increasing household income within forest communities in Cameroon. Its cultivation has also contributed to reforestation, agroforestry and sustainable development, and reductions in open bush fires and land degradation, contributing to combating desertification and climate change.

Keywords: desertification, deforestation, CO_2, poverty alleviation

Introduction

Forests, watersheds and river basins are being unsustainably used to overcome the challenges of poverty and hunger, resulting in destruction of watersheds and forests. Deforestation, overlogging, pollution and open bush fires all contribute to CO_2 emissions into the atmosphere while reducing carbon sequestration potential. Ecosystems that served as sources of water, food, fish and building materials have disappeared. Many freshwater animals and some highly valued plants have disappeared within certain communities.

Conclusions

Cocoa agroforestry offers a significant opportunity to combat these trends. Many families survive because of its cultivation. Cocoa plantations favor the growth of a thick forest and the flourishing of subsistence crops like banana, cassava and pepper as well as other vital animal and plant species. For example, edible land snails will proliferate, bees will become established and very rich organic manure is produced.

Decomposed cocoa tree leaves and cocoa shells return rich organic nutrients to the soils, allowing the cocoa tree and other plants to flourish while protecting soils from degradation and erosion. Soils remain moist in very hot temperatures (drought conditions) and smallholders can continue farming. Cocoa provides income to families from sales of the beans as well as enabling additional income from the allied crops made possible due to the improved soil and microclimatic conditions within cocoa estates.

Recommendations for decision-making

Cocoa growth and cultivation helps the poor to mitigate as well as adapt to desertification and climate change. Therefore cocoa farming should be encouraged through policy and technical support. Cocoa estates should be protected from degradation through assistance to local communities, non-governmental organizations and other relevant institutions.

Watershed management in the Democratic Republic of Congo

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Abstract: Water drives the growth of the vast forests of Democratic Republic of Congo (DRC) that are strategic carbon sinks for the entire world, capturing and storing carbon dioxide to combat climate change. Thus water management in DRC is important to the global community as well as to alleviate poverty in DRC. To achieve both these aims the DRC needs capacity-building and transfers of technology on water management.

Keywords: Watershed management, drought, desertification, rainfall, irrigation, agriculture, transfer of technology, erosion, floods, poverty alleviation, climate change adverse effects

Introduction

DRC comprises 2,345,000 km², of which 2,500,000 km² are covered with water sources: numerous rivers, many great lakes, a portion of the Atlantic Ocean, and wetlands.

DRC shares three basins with nine neighbor countries: Congo Basin, Nile Basin and Ciloango Basin. Those water sources determine the inhabitants' living conditions. Their importance is chiefly obvious for the large Congolese forest, located in the wet zone. They can procure many benefits for the local people, but improvement of living conditions depends on adequate management of water in rural areas by:

- developing techniques to collect and keep rainfall
- using irrigation schedules covering dry periods and so allow plants to receive water throughout the year.

Indeed, these practices are related to climate change, drought, soil degradation and land conservation, food security and poverty alleviation. There are many examples that illustrate the following concepts.

Climate change leads to rainfall perturbation. The quantity of rain in the region decreases or increases, destroying the crops by droughts or floods. Erosion, or excess or decrease of rain disturbs the growth of plants and leads to food shortages. As rainfalls are irregular, the solution is to stock water for use during the periods of drought. The quantity of water to stock depends on the type of soil: sandy, kaolin or other. We notice that long droughts will dry our rivers, obliging rural populations to carry heavy loads of water over long distances. In such a situation, we need special and technical methods to stock water for domestic use (cooking and washing) and to irrigate our fields and gardens.

Worse is the obligation of entire villages to move to find a favorable place near water to build their new dwellings. It should be noted that in most of African societies, family water supply is managed by women, and thus gender is an additional area calling for a quick solution from the international community.

Recommendations for decision-making

Our wish is to see the Committee of Science and Technology to finance scientific research in DRC; we ask this institution to fund various projects we present to combat climate change adverse effects in general, and particularly desertification and drought, enabling poor people in DRC to conserve water for domestic use and irrigation. Thus, we'll be able to alleviate poverty in DRC while combating climate change and desertification.

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Poster sessions

II. Asia

Diagnosing and minimizing nutrient depletion-related land degradation in the semi-arid tropics

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Abstract: Analysis of a large number of soil samples collected from farmers' fields in different states of semi-arid tropical India showed that soils were low in organic carbon, low to moderate in available phosphorus and generally adequate in available potassium. However, the widespread deficiencies of sulfur, boron and zinc were most revealing; and their deficiencies varied with nutrient, soil type, district and state. On-farm trials conducted showed significant yield responses of several field crops to the applications of sulfur, boron and zinc over farmer's input treatment; and the yields were larger when sulfur, boron and zinc were applied along with nitrogen and phosphorus.

Keywords: dryland agriculture, soil testing, nutrient deficiencies, major and micronutrients

Introduction

It is recognized that crop productivity in the semi-arid tropical regions is greatly influenced by water shortages caused by low, highly variable and erratic rainfall and low soil fertility, so much so that productivity of the rainfed systems even at subsistence level is threatened. Severe depletion of the soil nutrient reserves is due to various soil processes including erosion, crop removals and imbalanced and meager input of nutrients (Rego et al. 2007). This is resulting in sub-optimal productivity even in the areas with assured rainfall (750–1100 mm annual rainfall). More efforts are needed for diagnosing and managing the nutrient-related problems in farmers' fields on a practical scale in the semi-arid tropical regions of India. The ongoing integrated watershed management program by ICRISAT and its partners provided the opportunity to diagnose the soil infertility-related problems by soil testing; and to determine on-farm crop responses to fertilization in the semi-arid tropical zone of India.

Body of work

We have developed and validated cost-effective stratified soil sampling method to assess soil health status of a 500–1000 ha micro-watershed (Sahrawat et al. 2008). A large number of soil samples collected from farmers' fields in various states of semi-arid tropical India were analyzed at the ICRISAT Charles Renard Analytical Laboratory for soil fertility parameters. Soil test results showed that the farmers' fields were low in organic matter, low to medium in available phosphorus and largely adequate in available potassium. The most revealing results however, were the widespread deficiencies of sulfur, boron and zinc in the soil samples (Rego et al. 2007; Sahrawat et al. 2007). The deficiencies of sulfur and micronutrients varied with nutrient, soil type, district, and state. A large number of on-farm trials conducted for several years demonstrated significant yield responses (30–70%) for several field crops to the applications of sulfur, boron and zinc over farmer's input treatment; and the yield responses were still larger increased when these nutrients were added along with recommended rates of nitrogen and phosphorus.

Conclusions

The science-based approach to diagnose nutrient deficiencies using soil testing and follow-up farmer participatory on-farm trials based on balanced plant nutrient management can unlock the potential of rainfed agriculture in semi-arid tropical India and other developing countries.

Recommendations for decision-making

A soil test-based, site-specific nutrient management strategy should be used to sustainably enhance the productivity of food and feed crops in the rainfed areas of semi-arid tropical regions. The most practical means will be to prepare maps showing nutrient-status of famers' fields at the district and village levels to facilitate judicious and efficient use of fertilizers by farmers.

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Identifying systems for carbon sequestration and increased productivity in semi-arid tropical environments

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Abstract: Carbon stocks were estimated for representative in semi-arid tropics India. Using minimum and maximum threshold limits of soil organic carbon (Pg/mha) and bulk density, 22 systems were identified for carbon sequestration. The level of management adopted for the last 25 years increased soil organic carbon, indicating these soils respond to controlled management interventions. However, the simultaneous rise in soil inorganic carbon due to formation of calcium carbonates indicates a warning signal for soil degradation.

Keywords: soil carbon stocks, semi-arid tropics, carbon sequestration, soil degradation

Introduction

The sustainability of cropping systems demands a focused attention to monitor soil quality. Soil carbon stock has been found to be a robust soil quality index. Monitoring this soil quality and health requires basic information on soil organic and inorganic carbon stocks at different time intervals. This becomes more important with the growing concern about the decline in soil productivity and the impoverishment of soil organic carbon caused by intensive agriculture practices. To combat such situations, taking stock of soil organic carbon and also of soil inorganic carbon forms an essential prerequisite in land resource management. Due to the presence of characteristic smectite minerals, black soils (Vertisols and their intergrades) have the projected potentiality of sequestering soil organic carbon stock of 14.02 Pg (1 Pg = 10^{12} g), which is 3.7 times more than the existing stock (Bhattacharyya et al. 2008). The present study is therefore focused in prioritized areas of semi-arid tropics, India, to identify systems for carbon sequestration and increased productivity, as well as to focus attention on the increased soil inorganic carbon (Bhattacharyya et al. 2007a).

Body of work

Clayey and smectitic red and black benchmark soils covering a 15 million ha area in semi-arid tropics were studied under different land use systems viz. agricultural (cereals, soybeans, cotton), horticultural (mandarins), forest (teak and sal) and wasteland to identify land use systems for carbon sequestration. Under each land use system and two managements (high management and low management), soils under high management showed higher soil organic carbon and are darker in color; and their consistency is controlled by slickensides, $CaCO_3$, zeolites and gypsum content. Roots were found concentrated in soil layers containing low $CaCO_3$. Based on the stocks of total soil organic carbon, soil inorganic carbon and total carbon, 22 production systems were identified as viable under the current level of management using threshold levels of soil organic carbon (Pg/million ha) and bulk density (Bhattacharyya et al. 2007a). The datasets generated during two time scales (1980 and 2005) were utilized for monitoring soil health. The increase in soil organic carbon stock was evident although the higher level of soil inorganic carbon indicates a warning signal for soil degradation for last 25 years. The increase in soil organic carbon shows that these soils in semi-arid tropics respond to management systems. However the rise in soil inorganic carbon warrants a fine-tuning of the existing management interventions (Bhattacharyya et al. 2007b). The results on the effects of various production systems in the semi-arid tropics, with emphasis on rice vs. other upland systems, showed that soil samples from sites under natural vegetation had the highest contents of organic

C and total N, followed by those under lowland rice cultivation and other upland crop production systems. Thus the soil under continuous wetland rice cropping accumulated organic matter and contained higher soil organic matter compared to the sites under other upland cropping systems (Sahrawat et al. 2004).

Conclusions

The study developed the techniques to find out threshold limits of soil organic carbon and bulk density in identifying systems for better carbon sequestration and increased productivity. The data set of soil parameters out of 22 identified systems will greatly help the soil modelers engaged in soil organic carbon enhancement and increased soil productivity in semi-arid tropics. The datasets of each benchmark location could also be used for monitoring soil health.

Recommendations for decision-making

Although the unique role of soil as a potential substrate in mitigating the effects of atmospheric CO_2 has been highlighted by scientists, the present study demonstrates the pathway of the sequestration of atmospheric CO_2 in the form of soil inorganic carbon and its subsequent role in contributing soil organic carbon in the drier parts of the country. Rehabilitation of calcium carbonate containing sodic (with high exchangeable sodium) soils through appropriate management interventions causes dissolution of carbonates through acidic root exudates and carbonic acid (H_2CO_3) formed by CO_2 evolved from root respiration to improve drainage. The CO_2 evolved goes back to atmosphere to complete the C-cycle. This pathway of C-transfer from inorganic (atmospheric CO_2) to organic (CH_2O), and organic (CH_2O) to inorganic (CO_2 in soil and then to $CaCO_3$), which indirectly help in better vegetative growth (organic) in improved soil environment (good structure, better drainage), is largely active in soils of semi-arid tropics. Through management intervention by improving vegetative cover, these soils containing huge soil inorganic carbon stocks could be ameliorated with two-fold gains viz. (i) sequestration of organic carbon in soils through plants and (ii) dissolution of soil carbonates by root exudates to improve soil structure and thus to combat further soil degradation (Bhattacharyya et al. 2004).

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Soil and water management technologies to minimize degradation and sustain agricultural productivity in the semi-arid tropics

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Abstract: Land degradation, water scarcity and resulting productivity losses are the major challenges to dryland agriculture, threatening the livelihoods of millions of poor in developing semi-arid tropical countries. Increasing degradation of resources and lack of knowledge render cash-poor farmers more vulnerable to drought, other natural disasters and impacts of climate change. In most semi-arid tropical regions, the alarming scarcity of surface and groundwater demands appropriate strategies to achieve food security and improve livelihoods in the semi-arid tropics. The main challenge is to enhance adoption rates among individual smallholders and their communities of various *in situ* and community-based soil and rainwater management technologies to enhance crop yields while minimizing land degradation. ICRISAT, along with partners in Asia, successfully tested several cost-effective field- and community-based land and water management practices through participatory community watershed management in India, Thailand, Vietnam and China. Cost-effective small water harvesting and groundwater recharging structures are easier to construct and maintain by the community. Improved rainwater management interventions increased green water (soil moisture) and blue water (harvested runoff and groundwater) across the watersheds in different rainfall zones.

Keywords: Field-based soil and water management, low-cost water harvesting structures, integrated watershed management, semi-arid tropics and land degradation

Introduction

In most semi-arid tropical regions, there is an unholy nexus between drought, land degradation and poverty. Drought affects livelihoods, pushing people deep into poverty. Progressively worsening poverty does not allow people to invest on improving land productivity and crop management, which results in poor crops and further degraded lands. Poor land productivity worsens the situation by contributing to agricultural drought. This nexus needs to be broken in order to improve the livelihoods of millions of rural poor residing in the fragile agro-ecosystems (Wani et al. 2006). In this nexus, water is the key issue. Rainfall in the semi-arid tropics generally occurs in short torrential downpours. Most of this water is lost as runoff, eroding significant quantities of precious topsoil. The current rainwater-use efficiency for crop production is low, ranging from 30 to 55%; thus annually large percentages of seasonal rainfall is unproductive, lost either as surface runoff or deep drainage. Groundwater levels are depleting in the region and most rural rainfed areas are facing water scarcity and drinking water shortages in summer season (Dar et al. 2008; Pathak et al. 2007). Rainfall, which is the main source of water for agriculture, needs to be managed effectively through its conservation and efficient use for reducing poverty and to arrest land degradation. In this paper, the results from on-farm trials *in situ* and community-based land water management practices that were found promising for improving productivity and reducing land degradation on semi-arid tropical soils are discussed.

Body of work

In participation with farmers, several types of *in situ* and community-based water harvesting and groundwater recharging structures were implemented at on-farm watersheds in India, Thailand, Vietnam and China. Automatic weather station, runoff and soil loss devices were established. Necessary training and capacity building activities for various stakeholders were undertaken. The observations on rainfall, runoff, soil loss, groundwater, crop yield and other parameters were collected and analyzed.

Conclusions

Rainfed semi-arid tropical regions are the hot spots of poverty and malnutrition. In these regions, the process of water and land degradation is seriously undermining people's livelihood security, leading to poverty and distressed migration. In this region, water is the major constraint for increasing agricultural productivity and improving livelihoods of farmers. Our ability to conserve rainwater during times of abundance and effective utilization through field- and community-based soil and water management practices is key to sustaining agricultural productivity, including livestock husbandry. Results have shown an excellent scope of increasing agricultural productivity and reducing runoff and soil loss through improved soil and water management practices.

The improved technologies have given dramatic benefits, which include highly economic increases in crop yields, amenability to small farmer's requirements and marked reduction in soil erosion, and have substantially increased water availability and utilization. Increased surface and groundwater availability resulted in increased cropping intensity and diversification to more remunerative land use systems involving livestock and horticultural and vegetable production. Field-based soil and water management and low-cost water harvesting and groundwater recharge structures were found to be most beneficial, cost effective and sustainable. These practices can play a vital role in conserving soil and water resources and improving livelihoods of the community. However to get the maximum benefits, these improved practices should be part of integrated watershed management.

Recommendations for decision-making

It is recommended that both the field- and community-based soil and water management interventions should be used for conserving soil and water resources and increasing agricultural productivity. Simple and low-cost water harvesting and groundwater recharging structures and other interventions should be given high priority.

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Improved livelihoods in the Asian semi-arid tropics through a community watershed management approach

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Abstract: The semi-arid tropic region, spread over 55 developing countries, is a hotspot of poverty, malnutrition, severe land degradation and water scarcity. These fragile ecosystems can be sustainably managed by adopting an integrated watershed development approach resulting in increased rainwater use efficiency as well as increased groundwater availability for sustainable development, reduced soil loss and reduced loss from runoff (45%) and balanced use of land nutrients, and minimized land degradation. Collective action with enabling policies are needed to rehabilitate degraded lands in the watershed. The watershed development benefited landed as well as landless and women members of the community by improving their livelihoods and reducing distressed migration.

Keywords: community watershed, rainfed agriculture, improving livelihoods, land degradation

Introduction

The semi-arid tropic region spreads over 55 developing countries and is characterized as fragile ecosystems with prevalent water scarcity and which are prone to severe land degradation. The semi-arid tropic region is also a hotspot of poverty, malnutrition and poor infrastructure. The rainfed areas cover 60–99% of the agricultural cultivation in different countries of Asia and Africa. A close nexus between poverty, land degradation and water scarcity exists. The recent Comprehensive Assessment of water for food and water for life globally as well as watershed programs in India have established that current farmers' field yields in developing countries are lower by two- to four-fold the potential crop yields obtained by the commercial farmers and researchers. ICRISAT and its partners have developed a holistic farmer-centric integrated watershed management approach for improving livelihoods by unlocking the potential of rainfed agriculture.

Body of work

A small catchments watershed development approach is a viable option for unlocking the potential of rainfed areas and doubling or quadrupling the productivity through augmenting water resources and minimizing land degradation in the rainfed areas (Rockström et al. 2007, Wani et al. 2007 and 2009). Based on the learning from the strategic and on-farm development research, an ICRISAT-led consortium has developed an integrated watershed development model for enhancing the agricultural productivity through increased rainwater use efficiency by adopting an integrated genetic and natural resources management approach. The integrated watershed development approach espouses collective action, convergence, capacity building and a consortium approach to address the issues of equity, efficiency, economic gain and environment protection. Tangible economic benefits to smallholders, good local leadership, technical backstopping by consortium, a pre-disposition to collective action and need-based productivity enhancement interventions, along with micro-enterprises to benefit landless people, are identified as drivers for promoting collective action in the community watersheds. Benchmark nucleus watersheds at Lucheba in Guizhou and Xiaosin-cun watershed in Yunnan are provinces in Southern China, Tad Fa in North-East Thailand, Thanh Ha and Huong Dao watersheds in Northern Vietnam and number of watersheds in Central and Southern India have demonstrated the power of the consortium approach to minimize land degradation, enhance natural resource use efficiency and increase productivity to improve livelihoods for sustainable development of the dryland areas in the semi-arid tropics. Through diversified livelihood systems, incomes of farmers as well as landless marginalized groups are substantially enhanced even during drought years.

Conclusions

Community watershed management can become a growth engine for sustainable development of dryland agriculture in developing countries using water management as an entry point to improve livelihoods through knowledge-based natural resource management options. Reduced soil loss, increased rainwater harvesting and recharging groundwater, increased greenery, carbon sequestration, biodiversity with increased productivity and incomes showed that an integrated watershed approach is a win-win-win strategy to minimize land degradation, improve livelihoods and achieve sustainable development. By adopting this approach, productivity of crops (maize, groundnut, sorghum, cotton, pearl millet, pigeon pea and chick pea) could be increased by two- to four-fold. The integrated watershed development program resulted in multiple benefits and impacts by increasing productivity by up to 400% and improving water availability through increased groundwater as well as surface water, resulting in increased cropping intensity doubling their incomes in 4 years.

Recommendations for decision-making

- Increased investments in rainfed agriculture are urgently needed to achieve sustainable and equitable development in the semi-arid tropics.
- A science-based community participatory and holistic watershed approach should be adopted to minimize degradation of natural resources and improve rural livelihoods in the semi-arid tropic regions.
- Technical backstopping through a consortium of institutions is needed to enhance the impact of watershed development initiatives in the semi-arid tropics in Asia and Africa.

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Impact of climate change and coping strategies in the Asian semi-arid tropics

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Abstract: Climate change and land degradation will negatively impact agricultural production systems in the semi-arid tropics and thereby increase the vulnerability of poor people in these regions. Community-based integrated watershed management, which incorporates implementation of resource conserving and productivity enhancing technologies, will help in reducing land degradation as well as coping with climate change impacts in the semi-arid tropics. Diversification of farming systems and livelihood options would help the poor to overcome the livelihood risks associated with climate change and land degradation. Capacity building of stakeholders, institutional arrangements and policy advocacy will be the essential features of the overall strategy to reduce land degradation and to meet the future food needs of people living in the region.

Keywords: climate change, semi-arid tropics, watershed development, coping strategy

Introduction

Increasing land degradation or growing losses in productivity of agricultural production systems and increasing vulnerability of smallholders and poor people in the SAT are expected to grow due to the anticipated impacts of global warming and associated climate change (IPCC 2007). In view of the urgency to achieve a food secure world and meet the Millennium Development Goals of sustainable development and poverty reduction, we need to develop coping strategies for increased food production that will provide resilience to the rural communities as well as the natural resources they depend upon for their livelihoods.

Body of work

ICRISAT and its partners have adopted the integrated genetic and natural resource management approach to develop adaptation and mitigation strategies to cope with climate change by adopting participatory community watershed management. As a part of a multi-prong strategy, ICRISAT has developed "climate ready" high temperature-, drought- and disease-tolerant cultivars of pearl millet (HHB 67), groundnut (ICGV 91114) and "early" and "super early" chickpea (ICCV 2), which have produced higher grain yields under adverse climatic conditions than the current cultivars grown by the farmers. For more efficient and sustainable use of natural resources (land, rainfall, nutrients and vegetation) in variable climates, ICRISAT is promoting community-based integrated watershed development and management to enhance productivity, income and livelihoods of the rural communities (Wani et al. 2003, 2004). Diversified livelihood options along with diversified cropping systems such as livestock management, poultry and micro-enterprises in these watersheds are helping farmers to manage risks associated with climate change. As part of the mitigation measures, ICRISAT is studying the utility of *Jatropha curcas* and *Pongamia pinnata* on degraded lands for bio-diesel production and sweet sorghum on marginal lands for ethanol production without compromising food security. These technologies not only provide vegetation cover to the degraded lands but also help in sequestering more atmospheric carbon into the soils. Management practices such as legumes in rotation, minimum tillage, soil and water conservation measures that can improve soil health through increased carbon sequestration, as well as increasing crop production and farmers' incomes are developed and evaluated with community participation. Capacity building of stakeholders, institutional arrangements and policy advocacy are the essential features of the overall strategy to cope with climate change.

Conclusions

Community-based integrated watershed management in the rainfed areas of the semi-arid tropics, incorporating integrated genetic and natural resource management approaches, will enhance agricultural productivity, reduce land degradation and protect the environment. Diversification of farming systems will increase productivity and generate multiple sources of income for the rural poor to cope with risks associated with climate change and land degradation. Greening of degraded lands in watersheds with bio-fuel plantations will not only provide additional income to the rural communities, but will also reduce land degradation and mitigate climate change by replacing the use of fossil fuels for energy and increasing carbon sequestration.

Recommendations for decision-making

Conservation and management of natural resources through integrated watershed management needs to be promoted and supported in the more vulnerable rainfed regions of the semi-arid tropics by the national and international research and development agencies. This will not only enhance sustainable food production to feed the growing populations, but will also help protect and rehabilitate the natural resources for future generations.

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Using indigenous knowledge for monitoring desertification: community-based decision support systems in India

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Abstract: Indigenous knowledge systems have been in practice since time immemorial, but their utility in decision-making for sustainable land management was never mainstreamed as a tool for tackling the problem of land degradation in India. With the advent of peoples' participation in natural resource monitoring and land management, these practices have been gaining considerable importance, and assisting in improvement of management practices for land resources in central India. Using action research for gathering evidence of indigenous knowledge from field sites (in central India), the research poster draws on the learning from community participation and indigenous knowledge systems for monitoring sustainability of land systems in central Indian forests, which can suitably be leveraged for monitoring desertification and improving land management practices in the country.

Keywords: sustainable land management, indigenous knowledge, community-based decision support systems

Introduction

Land systems in central India are extremely vulnerable to anthropogenic stressors, including: deforestation, land-use change, intensive agriculture, rapid urbanization and growing demand for natural resources. These stressors cause acute water resource scarcity and biodiversity loss, adversely impact ecosystem services, and ultimately lead to desertification. Due to the sheer magnitude and size of these land systems, the state machinery (viz forest departments) face immense challenges in monitoring the bio-physical indicators of desertification and land degradation. The stressors cast their greatest impact especially in rural/forested areas of India, where nearly 400 million people are dependent on forest land for their livelihoods. Hence a user-friendly, cost-effective and robust system for periodic monitoring of bio-physical and socio-economic indicators of land degradation is a necessary prerequisite for sustainable land management.

Body of work

Earlier in the 1990s, the forests were managed by the state forest departments under bureaucratic guidelines and stringent procedures. The indigenous communities (who constituted a major portion of the rural populations) were not given the right to voice their concern regarding the management of land resources (either on public, community-managed or leased land). As a result, the indigenous knowledge systems that were passed down from their ancestors over generations were not given due regard and remained 'in the closet' in the form of traditions and folklore.

Since the Joint Forest Management regime (resolution passed in 1990), the forest departments and the communities have been jointly managing the forests and land resources. Assisted by developmental interventions and internationally funded projects in central Indian state of Madhya Pradesh, the indigenous communities are now monitoring desertification and forest sustainability and measuring the vulnerability of forests to degradation using 'indigenous knowledge-based indicators'. These indicators are regularly monitored using local tools and simplified procedures for data collection and analysis. Due to these knowledge systems and a conducive policy environment, the bio-physical and socio-economic indicators for land degradation are being monitored and the vulnerability of the ecosystem has been substantially reduced.

This community-based decision support system, which blends traditional knowledge systems of indigenous communities and modern methods of land resource monitoring, is showing favorable results in central Indian forest lands. It is also helping the state agencies in the monitoring and mapping of desertification and land degradation by providing the latest data on the status of land resources, and thus helping them to take timely and necessary action.

Conclusions

The indigenous communities that make up the Joint Forest Management Committees comprise the people whose lives revolve around rural landscapes, and hence they are best placed to participate in and contribute to the monitoring, assessment and mapping of land resources. With the contribution of the international donor community (including World Bank-funded projects, FAO's research, the International Tropical Timber Organization's project interventions etc), local capacity is being built at the grassroots level to enable indigenous people to use their traditional knowledge systems. Eventually a participatory adaptation mechanism has come into being which ensures that these knowledge systems help in monitoring the land resources, thus ensuring long-term sustainability of the land resources. The knowledge system is also helping to assess research gaps and develop effective communication channels between the state forest departments and community-level institutions. Thus indigenous knowledge systems have proved to be successful in improving the robustness of data collected during monitoring and assessment of land and forest resources. Nationally, there is an urgent need for streamlining these systems into a viable tool for achieving the goals of sustainable management of land systems.

Recommendations for decision-making

Though knowledge per se is a universal resource, indigenous knowledge has not been given its due importance within the land resource management framework and has not permeated the developmental strategies of state agencies. This is because indigenous knowledge is considered as an exclusive and personalized domain rather than a 'public good' that has universal utility and which is capable of appreciation, adaptation and growth. Adding insult to injury, the indigenous knowledge systems are generally looked-down upon as trivial methodologies, lacking in 'good science', and hence are often sidelined in the majority of developmental interventions.

The decision-makers must look into upscaling of indigenous knowledge systems for suitable adaptation and implementation in other states, and perhaps in other parts of the developing world. For achieving this objective, several other issues and challenges are to be tackled by decision-makers, including (but not limited to): alignment of indigenous knowledge with the demand for knowledge in mainstream developmental interventions for sustainable resource management, appropriate documentation of indigenous knowledge systems, transforming indigenous knowledge into workable policies and practices through pilot projects, and conducting rigorous research.

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Integrated watershed development through farm ponds to improve agricultural productivity in northeastern Thailand

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Abstract: Northeastern Thailand is known for its limited soil and water resources. Optimizing benefits differently according to conditions downstream vs. upstream in watersheds is recommended. Assessment of the impacts of the New Theory farming model on farmers having control over comparatively large ponds downstream in the watershed revealed that they allocated their lands in the proportions of 100:15–55–28–2 for pond body, paddy field, crop land, and farm facilities respectively which is only half the recommended pond allocation (100:30–30–30–10 with 7,700 m^3 water storage capacity to support more sustainable and remunerative dry season paddy, vegetable/field crops and crop-fish-animal farming). Farmers in these areas derived income proportions of 78%, 10%, 8% and 4% from paddy, fish, vegetables and fruit trees respectively. For farmers with smaller farm ponds in hilly upstream areas a farmer participatory approach introducing proper land use, water and crop management significantly increased water availability for crops while reducing soil loss to 5–6 t/ha-year compared to 25–33 t/ha-year in the traditional system. The upstream ponded water was mainly utilized for rainy vegetables and household-area crops, enabling additional income in the proportions 85%, 10% and 5% from vegetables, fruit trees and backyard herbs. Soil clay content plays a key role in water storage capacity in the upstream hilly areas whereas shallow groundwater levels are key in the downstream ponding areas.

Keywords: farm pond, integrated watershed management, small-scale water resources

Introduction

Northeastern Thailand is known as the poorest region in the country, with low agricultural productivity, a majority of poor soil and extremely erratic rainfall. Degraded soil with heavy land use after deforestation and runoff resulted in the emergence of shallow and skeleton soil in upland and an increase in saline and alkaline soil in lowland paddies. Large-scale schemes of soil and water resources development are limited (Thawilkal et al. 2005), but small-scale water resource development schemes in such of farm ponds designed to sustain agricultural productivity and reduce land degradation are recently being upscaled. Farm pond intervention is a key option.

His Majesty the King's initiative called 'New Theory Farm' provided laborers who were laid off from the ' Tom-Yam-Koong' economic crisis of 1997 with assistance to implement an integrated farming model in downstream lands. The New Theory Farm model sought to optimize food security and income by allocating downstream (rolling hill) farm area in the following proportions: pond (30%), paddy field (30%), crop field (30%), and farm facilities (10%). About 3,400 New Theory farm ponds were implemented in the Northeast (MOAC 2001)

Since 1999 in upstream areas, a holistic watershed management program on 'Participatory Watershed Management for Reducing Poverty and Land Degradation in Semi-Arid Tropical Asia' has been implemented as a multi-sectoral consortium approach coordinated by ICRISAT and Thai research organizations with financial support from the Asian Development Bank. It addressed comparatively smaller ponds of about 1,260 m^3 water storage in these upper watershed hilly areas (Thawilkal et al. 2007). The goal was to implement 252,200 farm ponds by 2008 (LDD 2004) especially in mini-watersheds where soil degradation and water shortage are high. A total of 56 units of these farm ponds were implemented in two benchmark watersheds of the project, including 17 farm ponds in hilly site of phase I and 39 ponds in the rolling site of phase II.

Body of work

The impact of farm pond intervention in terms of water availability, ponding water level and surrounding shallow ground water was measured weekly from 2005 to 2006. Technological changes, farmer practices and on-farm productivity were assessed by questionnaires and interviews. A total of 13 farm ponds in the rolling uplands site and another 2 in the hilly site were sampled in this investigation. A survey by questionnaire was conducted across 526 New Theory farm pond owners in Khon Kaen Province in 2007.

Conclusion

The New Theory farm ponds improved farm productivity and farming systems in downstream paddy fields. Meanwhile, upstream farm ponds could reduce sediment movement downstream and even save water. Farmers determine the best balance between water use for food security (producing paddy rice) and for income (rainy-season vegetables in hilly areas). Groundwater levels play a more significant role in maintaining pond water volumes in rolling watershed areas whereas soil texture (clay content) is more important in hilly areas. Farm pond integration with crops, sustainable soil management and timeliness of management are important for secure livelihoods small-scale watersheds.

Recommendations

Water management is just an entry point, not an endpoint, but community watersheds with farmer participation utilizing collective expertise have greatly improved water use. An integrated watershed approach with technical backstopping from multi-disciplinary teams from different institutions working together in a consortium can optimize the holistic benefits received from the watershed.

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Use of LADA for the development of a national SLM-information system for Uzbekistan

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Abstract: The paper describes the first application of international FAO LADA methodology in Uzbekistan/Central Asia. The project is carried out within the framework of the Central Asian Countries Initiative for Land Management (CACILM) Multicountry Partnership Framework Support Project, which assists the five Central Asian countries in adopting an integrated approach to land use planning and management. Development of design and national Sustainable Land Management Information System (SLM-IS) using FAO LADA methodology was a main objective of the project. Land use, land cover, socio-economic data, recent remote sensing (MODIS) and GIS data with other indicators have been used to establish baseline information for monitoring and assessment of changes in land management and rural livelihoods. Results include also climatic data and discuss drought issues for adaptation to climate change in the example of Uzbekistan.

The necessity of WOCAT and its readiness for adaptation in Uzbekistan are also described here. This paper provides useful discussions on monitoring and assessment of land degradation for decision makers in land and water management, and helps to draw strategy and mechanisms for connecting land degradation and climate change at national and local levels.

Keywords: land use / land cover change, climate, FAO LADA, monitoring and assessment

Introduction

The Multicountry Partnership Framework Support Project of CACILM supports the adaptation an integrated approach to land use planning and management, taking into consideration current international efforts towards a harmonization of land data and information management. In this context CACILM adopts the LADA methodology, approach and indicators to develop and design Central Asian SLM-IS at three levels as global, national and local levels. The case for Uzbekistan is presented here.

Body of work

Design and implementation of the SLM-IS in Uzbekistan was started in early 2008 as a development of baseline information on land degradation in the country and sub-regions and development of key indicators for monitoring, assessment and rehabilitation techniques for sustainable land management. The compilation of land degradation information has been supported by adaptation of the FAO LADA land use system approach. The guideline on approach and training materials was supported by FAO LADA team. The assessment of land degradation, hotspot and bright spot analysis has been conducted by interpretation historical and seasonal change of NDVI using MODIS (2007–08) and Landsat-7 data. Based on FAO LADA guidelines, the prepared national land use map was integrated into the global FAO land use system. The new jointly prepared with FAO land use system map of Uzbekistan (in scale 1:1 million, dated 2009) provides opportunities for the evaluation and mapping of land degradation and monitoring of sustainable land management in country level and ensures application and use of WOCAT knowledge base in the fields of desertification, salinity mitigation, soil and water conservation, crop diversification, agroforestry management and other improvements to mitigate impacts and enhance adaptation and mitigation of global climate change.

Conclusions

The established SLM-IS of Uzbekistan has: i) improved the current weaknesses the national data information base; ii) enhanced the countries' institutional capacity to assess and monitor land degradation and rehabilitation techniques; and iii) promoted information and data sharing between the national and multicountry systems as well as between CACILM and LADA, and other global systems.

It has brought together national group of Central Asian country experts from different institutions for harmonization of the generated information to adopt integrated land use planning and land management tools at local and national levels for decision-making.

The incorporation of the national SLM-IS into global land use systems will enhance: reliable monitoring and assessment and data sharing systems to more effectively combat desertification and land degradation; better bio-physical and socio-economic modeling and adaptation policy measures and management tools for decision-making in support of sustainable land management; and foster resilience against land degradation, droughts and other climatic challenges.

Recommendations for decision-making

The adaptation of LADA methodology and WOCAT knowledge bases is a useful framework to improve the effectiveness of monitoring and assessment of sustainable land management and to adapt policy and mitigation measures for land use planning and management at global, national and local levels.

Experience gained during design and implementation of the SLM-IS activities have clearly demonstrated the need for: (i) capacity building in new diagnostic and spaced-based management tools; (ii) a monitoring and assessment approach to enhance incorporation of national and multi-country sustainable land managementinformation systems into global spatial scales; (iii) improvement of knowledge and capability of institutional and scientific capacity on adaptation and mitigation of vulnerable arid ecosystems to climate change impact; and (iv) verification of theory in practice.

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Poster sessions

III. Latin America

Bio-physical and socio-economic impact of desertification in Mexico: a study case in La Amapola, Mexico

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Abstract: We apply a new conceptual framework for the integrative study of desertification, the Dryland Development Paradigm (DDP) in La Amapola Mexico, which allows the identification of key bio-physical and socio-economic factors. Considering these factors, we conclude that the community is not aware of the causes of land degradation and its implication on the hydrological sustainability of the landscape. It is necessary to take account of the hydrological cycle and of cultural community knowledge to establish effective policies for combating desertification.

Keywords: bio-physical and socio-economic indicators, environmental policy, water management

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Introduction

Desertification is one of the most significant environmental problems in drylands throughout the world. This is also the case in Mexico, where drylands comprise 50% of the territory and are home to 60% of the country's population. High variability in rainfall, coupled with increasing livestock numbers, have caused severe deterioration of plant cover, soil structure and the water retention capacity of drylands, resulting in increased runoff and, therefore, increased water loss and gully formation.

Body of work

The aim of our study was to apply the DDP, which is a holistic framework to address the inherent complexity of desertified landscapes by identifying how key socio-economic drivers interact with hydrological variables in a rural community in Central Mexico. The study system is characterized by patches of pine-oak forest, rangeland rainfed agriculture and abandoned agriculture. We examined how water inputs and outputs differed for four land-use types and how humans have adapted to changing hydrology in this landscape. We monitored precipitation and runoff at 10 sites in each land-use type and determined the proportion of plant and soil cover at each site. With new and dynamic methods such as consensus analysis, we explored the cultural consensus of climate change, environmental policy, soil water erosion and gully formation.

Conclusions

In La Amapola, where plant cover (mainly perennial grasses) was <10%, runoff was more than double in the nearby forests and active agricultural land ($P<0.0001$). In abandoned agriculture and rangeland the infiltration was three times lees in the nearby forest and active agriculture ($P<0.0001$). Taking advantage of economic incentives provided by government to increase livestock production, the La Amapola community increased water collection by building earth dams at the base of gully systems. This community does not distinguish the causes of the degradation of the earth and the impact of the livestock (shared knowledge), nor does it recognize the implications that these problems have for hydrological sustainability.

Recommendations for decision-making

In order to mitigate and restore degraded rangelands in this dynamic system, we must consider adaptive capacities, emerging opportunities and complex feedbacks within the landscape.

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Evaluating a new index as a drought monitoring tool

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Abstract: The knowledge of the regional pattern of dry days (days without rainfall) and their interannual-to-interdecadal variability could be a useful tool for monitoring of extreme conditions, such as droughts. Due to the complexity of the commonly used indices, the motivation of this research is to propose a new and easier index for drought monitoring. In addition, the temporal variability of this index adequately describes dry and wet periods in Argentina.

Keywords: drought monitoring, desertification, dry days, Argentina

Introduction

Desertification is land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities (UN 1993). Of the 270 million acres that make up Argentina, 60 million are affected by different desertification processes. The magnitude of social impact and economic losses is evident if we consider that the drylands of Argentina produce 50% of agricultural production and 47% of livestock (Manzano 2006).

Drought and wind erosion processes enhance the effect of water erosion on soil. These processes are intensified in areas where overgrazing and deforestation of native forests, associated with the expansion of agriculture, are usual practices. Drought periods are associated with high socio-economic costs and it is the interest of this research to evaluate the ability of a new index that could be used as a monitoring tool.

Body of work

The climate is one of the causes of desertification, and the lack of rain is one of the determining elements. We propose a new and simple index, called the lack of rain (LOR) index, based on the amount of dry days. The LOR index is calculated as the 12-month weighted moving average applied to the monthly anomalies of dry day time series. This index was considered for 83 rain gauges of Argentina. As in the Standardized Precipitation Index (McKee et al. 1993), the time scale of 12 months is the most suitable window for monitoring water resources (Cuadrat Prats and Vicente-Serrano 2004). Although the standardized precipitation index is frequently used, its main disadvantage is that its calculation requires several transformations.

The new index was evaluated for different time scales and compared with the standardized precipitation index. The correlation between both indices was statistically significant for different time scales. LOR index could also identify the development and evolution of the most important dry and wet periods throughout Argentina. The temporal analysis of LOR index was performed, accumulating the index during periods of 1, 2 and 5 years. This analysis shows that an increase in the amount of dry days dominated much of the country during the recent years. The most affected regions were the north-central portion of Patagonia and the Chaco's semi-arid region. However, other regions heavily affected by desertification processes, such as southern Patagonia, Cuyo region and the Northwestern portion of Argentina, showed lower amounts of dry days in the last 5 years (low values of LOR index).

Conclusions

Given the complexity in the calculations of most indicators related to desertification (Abraham and Salomón 2006), we propose the LOR index as a drought monitoring tool because of its simplicity. The proposed index is built using only daily precipitation data, without any transformation. This research concentrates primarily on drought monitoring, but LOR index is equally effective as a measure of both wetness and aridity. This tool is useful to be established operationally as part of a drought monitoring system because of its applicability at different temporal and spatial scales.

Recommendations for decision-making

A more efficient management of water resources is needed to meet the requirements of agriculture and drinking water supplies in the regions affected by an increase in the amount of dry days. Water resources management strategies must be adjusted according to changing conditions in the LOR index at a regional level, especially in the regions that are already affected by desertification processes. Also, a land rehabilitation program should be developed in Northwestern Argentina and Southern Patagonia, taking advantage of mild weather conditions occurring in those regions during the last years.

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Reimpulso de los Comités Regionales de Lucha contra la Desertificación

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Resumen: La conformación de los Comités Regionales de Lucha contra la Desertificación en la República Bolivariana de Venezuela, tiene como fin mejorar el proceso de ejecución del Programa de Acción Nacional para el manejo sustentable de las tierras propiciando el intercambio de saberes.

Bajo éstos lineamientos los Comités serán los promotores de espacios de encuentro entre los técnicos y las comunidades, integrándose en la formulación propuestas y ejecución de proyectos con buenas prácticas agrícolas en el marco de la autogestión, la cogestión y el principio de la corresponsabilidad.

Sus funciones, son impulsar la ejecución del Programa de Acción Regional, incorporando en él una estrategia financiera vinculada con los procesos de planificación Estadal. Igualmente, se aspira que sean un Foro de consulta para la elaboración de los Informes Nacionales que el país presenta a la Convención de Desertificación, y en la elaboración de otros informes y reportes.

Dado la convergencia interdisciplinaria, interinstitucional, y la participación protagónica comunitaria en los Comités, esto les da fortaleza para proponer temas, y gestionar proyectos de educación, investigación y de desarrollo socio productivos en las zonas áridas.

Palabras claves: Intercambio de saberes, desertificación, espacio de encuentro, financiera, comunidades, corresponsabilidad

Toward an alternative model for sustainable dryland development (Mendoza, Argentina)

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Abstract: This work shows the progress of a proposal aimed at influencing the combat of desertification and poverty through the use of territory resources, improvement and diversification of goat production, revegetation of degraded lands, reduced livestock pressure, increased producers' income and reinforcement of local actors' capacities to render new services. Desertification is studied and assessed as a complex problem through an integrated assessment procedure based on indicators and benchmarks. Work experience is located in the northeast of Mendoza in severely desertified drylands.

Keywords: combat desertification, sustainable local development, integrated assessment, Argentine drylands

Introduction

Mendoza is situated in the central strip of the Argentine drylands and 100% of its territory is desertified (Roig et al. 1991), a third of which is under severe processes associated with very poor conditions. The present work, framed within Argentina's national action plan, is conducted in the northeast of the province, which is representative of the Monte desert (Abraham et al. 2009) and comprises 2,000 inhabitants in an area of 10,000 km^2. Results can be extrapolated to the extensive central-west region of Argentina.

Current desertification models have been based on inventories of degraded bio-physical resources. This has conditioned response actions, promoting assistance intervention models which are confined to case studies and are generally driven by an interest to protect natural resources rather than local populations. This proposal balances the theoretical and methodological frameworks for land management and development, sustainable land use and combating desertification.

Body of work

Based on many studies conducted by IADIZA in the Lavalle desert, and as a result of the conclusions from the Feasibility Study (Enne and Abraham 2007) performed together with Desertification Research Group (Italy) and Spallanzani Institute (Italy), with the support of the UNCCD Global Mechanism, a research-action program was designed to generate strategies for local development and production diversification to combat desertification and poverty. The proposal leans on three pillars (associated with natural, economic and socio-cultural components) and, through local development, aims to achieve better land use, improve and diversify goat production, reduce livestock pressure and increase producers' income. Desertification status is addressed as a complex issue (García 2007), through a procedure of integrated assessment based on Benchmarks and Indicators (Abraham et al. 2006). The proposal combines innovative aspects of desertification assessment and monitoring, recovery and management of degraded lands for forage production, optimization of water resources, revegetation, establishment of nurseries, herd sanitation, design and demonstrative units directed to production diversification (healthy goat milk and by-products), capacity building in the local population and government, training of specialized technicians, promotion of producers' associations, support and technical assistance for product trading. The work combines diverse methodologies including participatory assessment procedures, thematic mapping, participant observation, remote sensing, field control and establishment of measurement plots (pastures, soil, water, climate and production units).

Conclusions

Current results indicate that dialogue and joint work among the population, local governments, research institutes and international financing agencies are of great importance for the coherence, depth and continuity of actions to combat desertification. It is necessary to work in interdisciplinary teams that go beyond the fragmentary visions of scientific specialties. Experience indicates this is the best way to work on mitigating the adverse consequences of desertification and reach its invisible causes, transcending isolated cases to tackle complex and dynamic problems at territory scale. Dialogues with local populations must exceed consultation levels, generating active processes of empowerment and equality in terms of decision-making. Systematic work with populations that struggle to exert their rights denotes the importance of attending, in the short term, to the possibilities of social reproduction of the groups in order to solve their unmet basic needs. Only thus will a balance between natural, economic and socio-cultural pillars be possible.

Recommendations for decision-making

- Promote intervention actions based on proposals for research-action and participatory local development planning and development of demonstrative units with potential for replication at territory scale.
- Attend to demands of local populations, safeguarding their needs for social reproduction and promoting associative activities.
- Add hierarchy to participation of local governments, supporting decision-making processes that go beyond the short term and are based on local populations' knowledge of their own territories and promote local investments in land management and recovery of natural and social capital.
- Support initiatives for sustainable local development by creating infrastructure and services in drylands to ensure better territory articulation.

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Jacobacci geographical assessment area of LADA Argentina

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Abstract: Jacobacci is one of the five Geographical Assessment Areas of the Land Degradation Assessment in Drylands (LADA) project in Argentina and is representative of north patagonian arid steppe with an extensive sheep wool production land use system. Bio-physical and socio-economic information was compiled for the area, group discussions with local people were conducted and a field survey on land degradation was carried out. The entire area was impacted by overgrazing: no undisturbed or lightly disturbed lands were found. Field survey data suggested different degrees of impact, controlled by landscape types and land use history. Although variables and indicators used in this work will be useful for land degradation assessment, more field surveys and a monitoring system are needed to assess desertification trends.

Keywords: land degradation, desertification, patagonian steppe

Introduction

Jacobacci is one of the 5 Geographical Assessment Area of the LADA project in Argentina. Located in Río Negro province, with an area of approximately 1,000,000 ha, the study zone is representative of north patagonian arid steppes. Annual mean temperature is 10.5°C and annual mean precipitation is 159 mm; rainfall occurs mainly in the cold season (sometimes as snowfall). The traditional land use system is extensive wool sheep production. Some farmers, mainly smallholders, began adopting extensive mohair goat production at around 1970. Land degradation in the area has been described by Speck et al. (1982) and a map of desertification was produced during a previous Argentine–German cooperation project (INTA-GTZ 1995).

Body of work

Bio-physical and socio-economic information of the area was compiled. Two group discussions with local people were held to better understand local perceptions on land degradation and changes in land use. A complementary regional historic review was also carried out, as well as a field survey on land degradation. Sampling plots were stratified according to principal landscape types (basaltic plateau, hilly lands, plains), including a few pairs of fence line contrast. Recorded data focussed on vegetation and soil properties such as vegetation cover, grass and shrub cover, cover of palatable and unpalatable plants, size of vegetated patches and inter-patches, indicators of soil surface conditions and soil organic carbon.

Conclusions

Local perceptions attributed land degradation is attributed to climatic trends but not to land use (overgrazing). No bright or hot spot areas were distinguished. Local people mentioned relative changes in land use; one change was the loss of some complementary intensive uses such as vegetable gardens. They considered that these changes were due to the Compulsory Scholar Law (circa 1950) that reduced the work capability of families as children and women attended schools located in towns far away from the isolated farms.

Analysis of the recorded information and field survey data revealed that the entire area was impacted by overgrazing. Historic information suggested that degradation processes may begin immediately after sheep production was rapidly expanded over the region. The relatively late occupation of these territories (the region was occupied by aboriginal nomadic hunters until 1885) allowed a massive introduction of sheep during a surprisingly short period. Land occupation occurred in a somewhat disorganized fashion, involving different social actors (Willis 1914) in a kind of 'wool fever'. It appears that no range management practices were applied and in many cases the numbers of grazing animals seemed to be regulated only by natural hazards such as droughts and strong snowfalls.

The entire area was impacted by overgrazing: no undisturbed or lightly disturbed lands were found. Field survey data suggested different degrees of impact, controlled by landscape types and land use history. Although variables and indicators used in this work will be useful for land degradation assessment, more field surveys and a monitoring system are needed to assess if the desertification process has been stabilized or if it is continuing.

Recommendations for decision-making

We considered that a field monitoring system is needed to assess desertification trends and to validate the ultimate impact of good practices. More complementary case studies are required to improve the monitoring system.

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Land use in arid lands: assessing desertification impact category in the western arid region of Argentina

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Abstract: In the last few years many studies have been done to define land use indicators in life cycle assessment context to evaluate the impacts that different products or activities produce on soil quality and/or biodiversity. In arid lands, human activities that require the intensive use of land may lead to a desertification phenomenon reaching an irreversible degraded state of soil and its life functions. This paper shows the desertification impact model developed for the mid-west arid region of Argentina and the results obtained by its application to a case study: the comparison between 1 m^2 occupied by brick production vs 1 m^2 occupied with rapeseed cultivation. The results show that agricultural activity results in a benefit in land properties, while brick production produces a harmful effect on the arid environment. This model, which was developed to assess the desertification impact of products, processes or activities during their entire life cycle, could be considered in life cycle assessment studies performed in the considered region, but also could be applied in other arid lands throughout the world.

Keywords: arid lands, case studies, desertification, land use, impact life cycle, impact assessment

Introduction

Human activities are associated with land occupation and transformation leading to environmental impacts. To ignore land use impacts in life cycle assessment reduces its credibility. In the last years several authors (Milà i Canals et al. 2007; Weidema and Lindeijer 2001; Cowell and Clift 2000; Lindeijer 2000; Köllner 2000; Müller-Wenk 1998) have proposed different methodologies to consider land use as an impact category, but there is no consensus on the definition of category indicators suitable within the LCA context or how to quantify the identified impacts. When assessing land use impacts in arid lands, it should be kept in mind that activities could result in a completely depleted and degraded state leading to desertification. It is therefore remarkable to consider desertification as a relevant impact on biodiversity and soil quality in arid regions.

This paper presents the application of a land use model developed for drylands to two case studies based on previous works by Civit et al. (2007); Arena and Civit (2006); Civit and Arena (2006), Nuñez et al. (unpublished) and Civit (2009).

Desertification impact model

To evaluate desertification impact, aridity index, vegetation cover and water balance were selected as the main indicators. The combination of them determines the reference state of each arid ecosystem, the so-called sensitivity factor (FSe), determined by a GIS. Desertification impact associated with a particular activity or product in a definite site is evaluated considering the same mentioned indicators and is expressed in ha-year. Sensitivity factors vary from 3 to 12, (3) being the most sensitive class to suffer desertification.

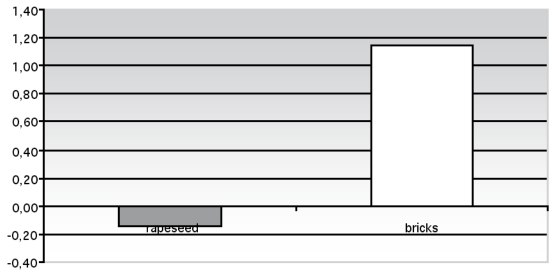
Selected case studies

Rapeseed cultivation (*Brassica napus*) in Junín, Mendoza and Craftsman brick manufacture in El Algarrobal, Las Heras, Mendoza.

Results

The desertification impact of the occupation of 1 m^2 of land with rapeseed cultivation and the occupation of 1 m^2 with a brick facility are -0.14 and 1.14 ha-year, respectively. Results are shown in Figure 1, which shows the relevant differences between both activities.

Figure 1: Desertification impact of the occupation of 1 m^2 of each activity considered



Conclusions and recommendations for decision-making

The negative value in rapeseed is interpreted as an improvement of soil conditions after the activity is finished. In that case, rapeseed could be a suitable alternative from the environmental point of view in arid regions because it helps to diminish the desertification process by buffering erosion effects, among other reasons. Also, it does not consume more water than is available, which is becoming a remarkable factor in a region where water is a scarce resource. On the other hand, brick manufacture, which is a very harmful activity, shows a positive impact, demonstrating a risk of causing desertification.

It can be said that the model developed is suitable and effective for quantifying the impact of land use in drylands. It quantifies a weighted impact factor for each reference ecosystem. The model could be extrapolated to any arid region of the world, provided the baseline information needed is available.

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The use of GIS to determine desertification characterization factors in the western arid region of Argentina

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Abstract: Desertification impact was proposed to be included among the impact categories in the life cycle impact methodologies to assess land use impact in arid lands. The desertification factor to quantify the impact caused by a product, process or activity during its entire life cycle was determined by applying a GIS. Overlapping different information layers, one sensitivity indicator was calculated for each arid ecosystem considered in the desertification impact model developed. This work describes the process to obtain the sensitivity factors for the arid ecosystems in the western arid region of Argentina. Four factors were obtained.

Keywords: arid lands, desertification impact, desertification factors, geographical information system, GIS

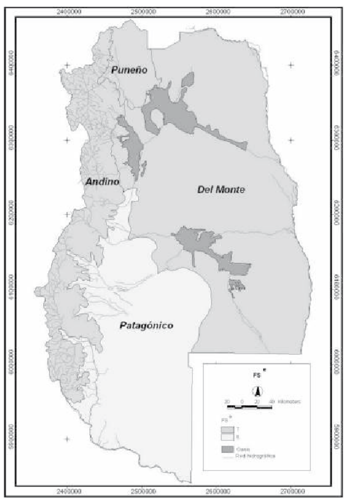
Introduction

For several years, life cycle impact assessment has incorporated land use as an impact category to assess land use impact of a product system or an activity that occupies or transforms a piece of land (Milá i Canals 2007; Weidema 2001; Lindeijer 2000). Despite the short history that land use impact has in the life cycle assessment context, many studies have been done aimed at defining land use indicators. Recently, Civit and Arena (2006), and Arena and Civit (2006) proposed to incorporate a 'desertification' impact category to assess land use impact in arid lands. Civit (2009) developed an impact model to calculate characterization factors for desertification. When assessing land use impact in life cycle impact assessment, many variables and parameters should be taken into account. The complexity of this practice leads to an objective solution to select accurate indicators for consideration and to treat information related to them. To solve this issue, it was decided to use a GIS because it allows the overlapping of many layers of information, not only spatial information but also biophysical information. This work describes the use of GIS related to the process of obtaining characterization factors of the four arid ecosystems considered in the desertification impact model developed for the western arid region of Argentina.

The use of GIS in the impact model developed

Information referred to type of ecosystems, aridity index, vegetation cover and water balance in the region considered was compiled in GIS-compatible databases. Ecosystem types were considered as the first (reference) information layer. The other three information layers – aridity index, vegetation cover and water balance – were overlapped on the first one. The addition of the four layers gave a factor of sensitivity to desertification, on a scale of 10 possible values, from 3 to 12, being 12 the lowest sensitivity. With the four factors calculated for each ecosystem type, a sensitivity map of the region was drawn (Figure 1). For the study case, the values calculated resulted in three ecosystems with sensitivity class 7 and only one with a sensitivity of 8.

Figure 1: Desertification sensitivity map in a case region (Mendoza province, Argentina)



Conclusions and recommendations for decision-making

Obtaining the desertification characterization factors for the arid ecosystems considered in the developed impact model allows researchers to reduce uncertainty when assessing land use impact of products, processes or activities that take place in arid lands. Thus, GIS becomes a powerful tool to calculate characterization factors for land use impact categorization in arid lands in different regions of the world.

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Mechanisms of desertification and sustainability in the arid and semi-arid region of northwest Argentina

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Abstract: Through the Regional Desertification Network (REDEN) integrated by research groups from National Universities of northwestern Argentina (Catamarca, Tucumán, Salta and Jujuy) joint efforts have been done to increase the effectiveness of environmental research and information. This is particularly applied in processes that cannot be understood with short-term small-scale or monodisciplinary research, eg climate change, land degradation and desertification. Knowledge of long-term processes and episodic events is gathered through site-based long-term monitoring, and large-scale processes can be elucidated by comparing data from distributed sites. This information obtained from regions with different bio-physical and socio-economical conditions would allow the establishment of management planning at the provincial or municipal level, in particular at sites were the local population, generally descendent of prehispanic populations, is affected by poverty and marginality.

Keywords: landscape deterioration, landscape resilience, sustainable management maximum

Introduction

Through REDEN, causal factors (human impact, climate variability, soil fragility and erosive landforms), the mechanism of present degradational processes, and the historical evolution of the landscape deterioration since the arrival of European during the 15th century are studied. The sample comprises areas representative of five geo-ecoregions: a) Puna Altiplain; b) dry Andes; c) arid preandean valleys; d) inter-mountain arid basins; and e) dry Chaco. Different research lines are in progress. Preliminary research results from the geo-ecoregion of preandean dry valleys are included in this abstract, in which a vision and understanding of important regional long-term large-scale environmental processes (eg desertification, climate change) and episodic events (eg droughts, floods) is presented. This would provide adequate information for appropriate environmental legislation and policy frameworks that are needed to maintain productive ecosystems and underpin sustainable development in the region.

Body of work

In the first part of the program, the valleys of Tinogasta/Fiambalá and Santa María (Catamarca and Tucumán province), were selected as sample areas because of a better accessibility and long-term history of land degradation. In the Tinogasta/Fiambalá sample area the relationship between desertification and landscape resiliency was studied (considered as the landscape recovery capacity after it exceeded a geomorphic, aedaphic and ecologic threshold).

In the preandean valleys, historically affected by extreme deforestation and overgrazing, different degrees of deterioration were detected, from areas where the resilience thresholds have been exceeded to small areas where an acceptable landscape capacity for cattle or goat raising is possible. In the Santa María Valley, a multidisciplinary toposequence analysis (integrating land form, soil and vegetation and keeping in mind the influence of climate in landscape dynamics) was carried on along the western slope of the Cumbres Calchaquíes ridge, from the high slope to the bottom of Santa María fluvial valley. The toposequence was divided into several steps in which vegetation cover and chemical soil parameters were measured in the dry and wet season for one year. Results showed extremely degraded areas in which no change in the seasonal vegetation cover was detected in contrast with others that were lightly disturbed and where a good cover was registered particularly during the summer.

Conclusions

REDEN is a facilitating regional project aimed at contributing knowledge of development possibilities of a huge territory that has been affected by intense deterioration during centuries.

Preliminary results show extremely degraded landscape with few productive possibilities (in the short term) in which resilience thresholds have been surpassed. In addition, there are several sites with less severe deterioration in which future productivity should be reflected by a systematic survey in different geoecoregion. Knowledge and understanding important regional long-term large-scale environmental processes (eg desertification, climate change) and episodic events (eg droughts, floods) should provide adequate information for appropriate environmental legislation and policy frameworks needed to maintain productive ecosystems and underpin sustainable regional development.

Recommendations

To detect different levels of landscape degradation by field monitoring and intensive use of remote sensing, keep in mind that mechanisms of desertification always have a local or regional particularity from a bio-physical, social and/or economical perspective.

Establishing friendly communications with the local people is a *sine qua non* condition, not only to get a good transference of technical aspects but also for the enrichment and comprehension of many aspects (physical and spiritual) of landscape dynamics that could be transferred by the native population (eg pastoralism strategies).

There is also a necessary condition to arrive at realistic conclusions on the evolution of the historical landscape and mechanisms of desertification and to find a good synergism between diverse professionals such as geographers, geologists, agronomists, economists and sociologists.

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Recovery and management strategies for degraded semi-arid rangelands of central Argentina

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Abstract: Semi-arid rangelands of central Argentina have suffered from severe overexploitation by grazing, resulting in degradation of both vegetation and soil. These changes are often difficult to revert due to positive feedbacks that lead to alternative stable ecosystem states. In this paper I analyze and discuss recovery and management strategies for the sustainable use of such ecosystems. The analysis points out that fire, in combination with grazing control and periods of favorable rainfall, could be used to restore and maintain a sustainable use of semi-arid rangelands.

Keywords: semi-arid rangelands, rangeland desertification, rangeland rehabilitation, sustainable grazing management

Introduction

Arid and semi-arid rangelands around the world have suffered from severe overexploitation by livestock grazing, resulting in degradation of vegetation and soil erosion. These changes are often difficult to revert due to positive feedbacks that lead to alternative stable ecosystem states (DeAngelis and Waterhouse 1987), and the spatial extensity of dryland ecosystems. Semi-arid rangelands of central Argentina conform to this situation (Fernández et al. 1989). Rangeland degradation is evidenced in the process of species replacement, loss of soil, reduced forage production and reduced carrying capacity. The objective of this paper was to analyze and discuss recovery and management strategies for the sustainable use of these rangelands.

Body of work

Rangelands of central Argentina are geographically located between 36 to 40° south latitude and 64 to 66° west longitude. The climate is temperate, semi-arid. Mean annual air temperature is 15°C, mean annual precipitation 400 mm (30% variation coefficient), and mean annual potential evapotranspiration 800 mm. Dominant soils are classified as Complex Calciustolls, of sandy/silty loam texture. Vegetation is composed by herbaceous and woody species. The herbaceous vegetation is represented by perennial palatable grasses (eg *Poa ligularis*, *Piptochaetium napostaense*, *Stipa clarazii*, *S. tenuis*), perennial unpalatable grasses (eg *S. speciosa*, *S. gynerioides*, *S. tenuissima*, *S. ambigua*, *S. brachychaeta*), and annual species (eg *Hordeum* sp., *Bromus* sp., *Schismus barbatus*, *Medicago minima*, *Erodium cicutarium*), whereas the woody vegetation is represented by caducifolius species (eg *Prosopis caldenia*, *P. flexuosa*) and evergreen species (eg *Larrea divaricata*, *Condalia microphylla*, *Chuquiraga erinacea*). *Lama guanicoe* was the main large herbivore in the region before the introduction of domestic livestock at the beginning of last century. Since then, there has been an overexploitation of vegetation by sheep and cattle. Fire has been a natural phenomenon in the region; before the introduction of domestic livestock, fire recurrence was probably no longer than 5–10 years (Bóo 1990), and since then a reduction in fire frequency due to fuel reduction and deliberate fire prevention by ranchers has occurred. Presently, these rangelands are in regular or poor condition (Llorens 1995, Distel and Bóo 1996). Overstocking, interacting with drought and fire exclusion are considered to be the main causes of rangeland degradation. This is evidenced in the replacement of palatable grasses by unpalatable grasses and/or annual species, increases in woody species density and cover, soil denudation and soil erosion.

Recovery strategies for degraded rangelands need to consider the spatial extensity that characterizes these ecosystems and related rehabilitation costs. From this perspective, fire emerges as a plausible alternative. The use of controlled fires could serve at least two relevant purposes: first, to reverse dominance of unpalatable grasses and woody species in favor of the dominance of palatable grasses (Bóo et al. 1996, 1997); second, to redistribute resources from vegetated patches to adjacent bare soil in combination with post-fire wind and water erosion (Ravi et al. 2009). The fire strategy needs in addition grazer control to allow for successful recovery of desirable vegetation.

Management strategies for the sustainable use of rehabilitated rangelands will require the appropriate control of stocking rate and grazing. Since drought occurs frequently, a sound strategy may be to adjust stocking rate to the carrying capacity in semi-drought conditions (precipitation around 20–30% below the annual mean). The excess of forage in normal or wet years could be used to fatten culled animals or grow yearlings, or for burning or recovering of plant vigor to better cope with future defoliations and droughts. However, the grazing strategy should be based on the maintenance of plant vigor to allow the expression of productive potential, reproductive capacity and competitive ability of the key species. The tactic to realize this strategy is to keep a minimal residual biomass for plant and soil protection, and allow for appropriate rest periods for plant recovery after defoliation. This in turn requires the operation of an efficient rotational grazing system.

Conclusions

Overexploitation by grazing, interacting with drought and fire prevention appear as the more probable causes for degradation of semi-arid rangelands in central Argentina. The use of controlled fire in combination with grazer control and periods of favorable rainfall (ie El Niño-like conditions) could be used to restore and maintain a sustainable use of semi-arid rangelands of central Argentina.

Recommendations for decision-making

The use of controlled fire in combination with favorable rainfall conditions and grazer control can facilitate recovery processes. Further on, the implementation of conservative stocking rates, minimal residual biomass maintenance and rest periods for the sustainability of improved rangeland conditions are recommended.

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Runoff and inter-rill erosion from rangeland in the semi-arid region of Argentina

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Abstract: In this region, overgrazing, deforestation and tillage modify natural vegetation and soil properties, increasing runoff and erosion. The objective of the work was to evaluate runoff and the soil loss in micro-sites with different grades of disturbance due to continuous grazing and tillage. To evaluate runoff and soil loss, a rainfall simulator was used. In natural grassland, runoff increases with impact because of animal treading; however, there were no important differences in erosion. In the deforested soils, runoff and, in a greater proportion, erosion increased significantly compared to soils under natural grassland.

Keywords: rangeland soil, soil erosion, runoff, rainfall simulator

Introduction

In areas of natural grassland in the semi-arid region, overgrazing and the decrease in the frequency of fire and deforestation have produced important changes in the vegetation and soils, so that the region presents an advanced stage of ecological degradation and desertification (Busso 1997). Distel and Boó (1995) described the changes of vegetation in terms of a model of state and transitions as a function of the history of grazing and frequency. Villamil et al. (2001) evaluated the degradation of the soils for different states of vegetation reporting important changes in the structure of superficial horizon and a negative impact in grazing on the physical properties of the soil. These changes produced in vegetation and soil affect the rate of infiltration (Echeverría et al. 2006), generating areas with high rates of runoff and erosion (Echeverría et al. 2002). These parameters have not been extensively studied in the region in spite of their importance. This study was undertaken in order to achieve an integral evaluation of soil loss in natural grasslands using micro-sites with different degrees of impact by continuous grazing and by deforestation. The research was conducted by means of runoff plots and simulated rainfall.

Body of work

In an overgrazed natural grassland in the south east of the province of La Pampa, several micro-sites responding to the following treatments were selected: P: Natural grassland grazed without treading, in areas adjacent to shrubs; PP: Natural grassland grazed and trodden in places between shrubs covered by perennial herbaceous vegetation; PAP: Natural grassland highly grazed and trodden on sectors with the presence of animal tracks: CPP: Firebreak grazed and trodden. Old forest trails covered by annual pulses (seeds); CA: Firebreak recently plowed.

To evaluate runoff and soil loss a rainfall simulator was used on plots 1 m^2 with two sequential simulated rainfall events in 24 hours, 30 minutes long with an intensity of 54 mm/h. Runoff was measured and the sediment was collected at intervals of 5 minutes. In each plot the vegetation cover, antecedent soil moisture content and characteristics of horizon A were evaluated.

The surface cover decreased greatly according to the degree of disturbance of the treatments. The average percentages for each site were: P=91, PP= 68, PAP=47, CPP=48 and CA=12.

The results show that there is an increase of total runoff with the degree of deterioration of the site. For P and PP the runoffs were minimal, with values equivalent to only 12% and 25% of the applied rain, while the site PAP generated a 68% runoff. For CA and CPP the values of runoff were similar and oscillated around 50%.

The average soil loss increased with the degree of disturbance and with the decrease in cover; average values were P=70; PP=77; PAP=379, CPP=859 and CA=2053 kilos per ha. Major erosion was found in deforested sites, where average soil loss was 8 times higher that in the forested situation. A lineal relation ($R2 = 80\%$) was found between soil loss and cover. The condition of antecedent moisture in the soil had an important effect, all treatments increased runoff and erosion during the second rainfall.

Conclusions

Under shrub conditions, runoff increased significantly with impact from animal treading, but there were no important differences in soil loss. In deforested soils runoff and, in greater proportion, erosion increased significantly with respect to soils under shrubs. In the condition of plowed soil, losses were significantly greater than the ones produced from treatments with cover and animal treading.

Recommendations for decision-making

Semi-arid natural grasslands in our country present a wide area of distribution and support many local and regional economies. Their inadequate use has provoked negative modifications in vegetation and in the quality of the soils, so it is necessary to implement management actions aimed at supporting production in the long term.

Further studies should be undertaken of simple management practices for grasslands that could improve the use of basic resources such as water and the physical condition of the soil. For example, evaluating the effect on the infiltration, runoff and erosion of livestock-rearing measures adequate for the animal load while maintaining grassland conditions, and evaluating rest periods and distribution of catering places to reduce treading. With respect to deforestation, ways of maintaining firebreaks should be evaluated and the usage of adequate systems of tillage that could avoid soil loss be explored.

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Biodiversity responses as ecological indicators of landscape degradation processes in the Argentinean Monte Desert

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Abstract: The semi-arid regions of Argentina have been subjected to accelerated desertification because of numerous human activities such as grazing, deforestation or agriculture. These activities produce changes in the spatial pattern of the landscape by altering a variety of ecological processes due to loss of natural habitats and reduced native species diversity. The central Monte Desert has an inherent natural heterogeneity, increased further by diverse pressures of land use since the time of colonization, and by land recovery for conservation. These complex scenarios of habitats recovered and under degradation processes can be monitored to disentangle the transitions to different conditions. Using different scales of analysis and organisms as a model of ecological change, our research shows how the structure of this disturbed matrix may affect biodiversity, and how the feedback from the local extinction or formation of new assemblages may have implications for biotic integrity in this semi-arid landscape.

Keywords: grazing disturbance, desert mammals, spatial scales, rangeland health

Introduction

Identifying environmental health conditions and desertification risk is a complex process that needs a new perspective where bio-physical dimensions such as soil and vegetation, which have been classical approaches, are integrated with animal biodiversity (Reynolds et al. 2005, Whitford and Bestelmeyer 2006). In the central Monte Desert in Argentina, grazing by domestic herbivores promotes environmental changes that produce a cascading effect on biotic factors and processes. Some components of native biodiversity, such as small and medium-sized mammals, have been used as successful models to examine this issue. Our research addresses the complex interactions triggered by grazing on the biodiversity of the Monte Desert, considering ecological changes in the grazed landscape at both coarse and fine scale.

Body of work

Extensive livestock grazing produces a landscape pattern with a high degree of gaps and a more heterogeneous scenario, in contrast to recovered conditions after a long-term grazing exclusion (Ñacuñán MaB Reserve) (Tabeni and Ojeda 2005). The development of landscape, left to its own spontaneous dynamics after grazing, promotes expansion of the shrubland and woodland patches, and increased plant density. This environmental heterogeneity plays a major role in understanding species responses to landscape changes caused by grazing impact. Recovered habitats can become either an unsuitable landscape for certain animals or, in some cases, be regarded as refuge and feeding sites for others. Animals requiring densely vegetated patches (eg rodents such as *Graomys griseoflavus*, *Akodon molinae* or *Galea musteloides*) compose the assemblages in recovered habitats, while the low number of open spaces in improved conditions could limit the occurrence and cause a decrease in richness or abundance of some endangered species, such as the endemic Patagonian hare (*Dolichotis patagonum*) leading it to use the open grazing matrix (Tabeni 2006). At fine scale, the spatially explicit analysis shows that the degradation gradients and the long processes of vegetation recovery imply high intra-habitat variability in the spatial distribution of life forms such as trees, shrubs and grasses. While vulnerable patches, such as grasses, increase their coalescence after exclusion, their dispersed clumps, under grazing, remain because of the structural protection afforded by woody plants. These dysfunctional signals in the habitat are perceived by the animals, who can overlap their distributions on these small relict patches (eg small rodents, *A. molinae*) (Tabeni et al. 2007), or decrease in abundance (eg *Calomys musculinus*). This can jeopardize some functional roles (eg herbivory, granivory, soil removal) and threatens processes such as water infiltration and germination among patches, regarded as key ecosystem functions to reverse degradation in the Monte.

Conclusions

The development of this anthropized matrix in the Monte has resulted in unique animal assemblages that occupy degraded and improved sites. From the viewpoint of the biota, this mosaic of different conditions means opportunities for the occupancy, or loss of shelter and food, with local extinctions and population decline. Moreover, the importance of animals affecting the dynamics of ecosystems from the whole landscape to the interior of the patches remains unexplored and requires a comprehensive approach at multiple scales. Understanding ecosystem changes is a consequence of the interactions among several factors, besides soil erosion, runoff and vegetation. A full suite of indicators that encompassing animal assemblages can facilitate recognition by decision makers of opportunities to achieve favorable or prevent undesirable transitions (Villagra et al. 2009).

Recommendations for decision-making

We base our recommendations on the following questions:

a. Do changes caused by grazing affect the biota of deserts? Decision-making for conservation, in view of the increasing degradation, must be prioritized, but under a new theoretical framework that considers the structural and functional diversity of the landscape, attentive to the preservation of key elements for the viability of animal populations, such as connection and flow between habitats.

b. Which processes could be altered by faunal change? The loss of biotic potential under degradation should be addressed, taking into considering the local extinction of species and also the formation of novel assemblages, which can exacerbate desertification processes. We need long-term ecological research to monitor changes in key interactions and feedbacks between vegetation, soil and wildlife.

c. Can these signs be used as early warning signs to prevent degradation? Since animals can be sensitive indicators of healthy conditions, we must incorporate the segment of biodiversity into an integrative approach to degradation processes.

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Modeling animal movements for sustainable use of extensive grazing systems at the Patagonian Monte (Argentina)

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Abstract: Animal movements result from complex organism-environment interactions and impact on the spatial dynamics at various levels of ecosystem organization and environmental processes. In arid ecosystems, large herbivores interact with vegetation processes involved in desertification. The spatial distribution of herbivores on the range is usually concentrated in groups and can severely impact on the condition of vegetation and create areas of desertification. Knowing the rules and mechanisms driving the movement behavior of domestic grazers contributes to the design of sound management practices of extensive grazing. We used long-term global positioning systems collaring of free-ranging ewes at a range in the Patagonian Monte (Chubut, Argentina) to develop a spatial explicit model of their movement behavior. Ewes perceived the range environment in a multi-dimensional context and their movements are influenced by several environmental drivers, including the local forage offer, the visibility range around the ewes` positions as limited by the geometry of the surrounding vegetation, the existence of previous trails and the time elapsed since the last access to a watering point. We discuss management practices to modify the distribution of large herbivores under extensive grazing conditions in the Patagonian Monte.

Keywords: herbivore movements, extensive grazing, arid shrubland management

Introduction

In arid shrublands, large herbivores must find their preferred food patches by negotiating plant structures that have heights nearly at or above the herbivores' horizontal visual range as well as strong chemical and physical defenses. Monitoring the spatial location of grazing animals in relation to vegetation traits helps identify rules related to animals' decisions about the selection of feeding areas and their impact on the persistence of plant species in arid shrublands. This information is needed to plan the distribution of herds within paddocks in order to avoid spots of land degradation within the context of adaptive management planning.

Body of work

We developed three experiments to evaluate the effect of three landscape characteristics on sheep movement paths at an extended paddock in Smit's ranch (–42° 38'S, –65° 23'W) at the Patagonian Monte (Argentina).

1. **Ewes' visibility range (*EVR*).** We developed a method to assess the relative intricacy of vegetation units (*VU*). We randomly selected four sampling sites of each *VU* across the paddock and three sub-locations, then obtained *EVR* estimations along eight horizontal sight-views equally spaced at 45° azimuth intervals at ewes' head height (0.7 m) at each sub-location. Views were obtained with a 200 mm, (focal ratio: 3.5) Canon Fb optical telemeter (Canon Inc. Tokyo, Japan) and *EVR* was defined as the distance (m) from the observer at which the focal plane showed 50% visual obstruction by vegetation For each *VU*, we further obtained the average *EVR* (4 sites × 3 sub-locations × 8 directions, n = 96) (Bertiller and Ares 2008).

2. **Forage quality.** We obtained 100,000 records of positions at every 1 minute for eight ewes (weight range 35–39 kg) at April 2005 (ewes 1, 2), September 2005 (ewes 3, 4, 5) January 2006 (ewe 6) and July 2006 (ewes 7, 8), harnessed with standard global positioning system receivers (e-Trex, Garmin, KS, USA) on their fore-

backs, while foraging at the selected paddock. We converted the position estimates to digital vector files into an application for image handling (IDRISI v 14.02, Clark Labs, Worcester, MA:, USA) and overlayed them onto the image files of the classified Landsat–7 image of the area in order to cross-tabulate the frequency of visits ($fp\,i$) at each vegetation unit. The position data were further used to compute movement velocities (m/min) between successive 1-min records and velocity vector files were similarly overlayed onto the image files of the area for cross-tabulation analysis. The selectivity Si exerted by sheep on a given VU_i was defined as the ratio: $S_i = fp_i \,/\, pa_i$, where fp_i is the frequency of positions of sheep on VU_i relative to all recorded positions and pa_i is the number of image pixels classified as VU_i respect to all image pixels of the paddock. Selectivity data of each *VU* were discriminated by sub-areas according to distances to the watering point (near, mid, far) and into two speeds: 0.5–3 m/min (slow movement, grazing predominant) and >3 m/min (fast movement, exploration predominant).

3. **Cultural transmission.** We overlayed the retrieved search trails on precision geo-registered (0.10 cm) aerial analog photographs of the grazed areas obtained during years 1965 and 2002 (Ares et al. 2007). Ewes searched along quasi-linear paths. When the present trails were overlayed on the year 1965 image, the paths also subtended areas of sparser vegetation than the regional average and many search paths were the same as those already existing.

Conclusions

We conclude that ewes allocate time along a series of similar movement efforts irrespective of forage availability at small patches. Average forage-scarcity at multi-patch level increases the ratio of searching/feeding time. This results in apparent selective time allocation to richer forage areas but does not imply evidence for oriented movement at a landscape scale. Ewes select areas of high visibility of the range even if local forage offer is lower than average at the landscape scale and use well-established trails to explore range areas.

Recommendations for decision-making

It is important to recognize environmental factors at a landscape scale that influence the distribution of herbivores in arid rangelands. Locally overgrazed areas constitute spots of incipient or advanced desertification and management should be oriented to modify the landscape conditions in order to avoid over-visited areas. Important factors to be potentially controlled at the Patagonian Monte shrublands are the height of the vegetation, the local forage offer and the existence of long used exploration trails.

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Rehabilitation and restoration to combat desertification in arid and semi-arid ecosystems of Patagonia

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Abstract: The following work summarizes experiences of rehabilitation in arid and semi-arid ecosystems with severe disturbance, where the recovery of the biodiversity at acceptable levels takes place over long periods of time. The study sites were located in the natural protected area Auca Mahuida and the area Aguada Pichana, in the Neuquén province, Patagonia Argentina. Seeds were collected in the degraded area to produce seedlings of the native species. Different experimental designs were applied using organic amendments, facilitation between species, and protection against herbivores, among others. The results show that the recovery in these ecosystems can be accelerated by means of technical ecological restoration. In Argentina this activity should be incorporated as tool to combat desertification in Patagonia.

Keywords: desertification, rehabilitation, survival, native plants

Introduction

The Neuquén province, located in Patagonia Argentina, has a high degradation level mainly due to overgrazing by cattle and extractive industries (Del Valle et al. 1995). The biological processes in these arid and semi-arid ecosystems are affected by the scarce and highly variable yearly rains, which determine a low primary productivity (Noy Meir 1973). Intervention through rehabilitation constitutes an alternative for the recovery of the vegetation of these ecosystems. This intervention requires investigation experiences in the field in order to contribute knowledge to institutions that combat desertification.

Body of work

The Auca Mahuida area is characterized by a peculiar vegetation of great botanical interest due to its endemics. It can be considered an island located in the phytogeographic province of the Monte, with flora and vegetation of the Patagonian Steppe (district Payunia) and High-Andean species in higher areas (Cabrera 1976). The mountains reach 2,258 m and the precipitation ranges between 180 and 320 mm annually, according to the altitude. In the area Aguada Pichana, the vegetation corresponds to steppe with shrubs. Its climate is dry and cool, with scarce precipitation (around annual 120 mm). In both areas, decapitated and dismounted soils are found. The vegetation was evaluated both in the degraded area and the reference area ecosystems, in order to determine which species to incorporate.

In Auca Mahuida we evaluated:

(i) Survival of *Senna arnottiana* associated to *Stipa speciosa var. speciosa*. The treatments were:
(1) *S.arnottiana-S.speciosa* with 1 l of polyacrylamyde powder;
(2) *S.arnottiana-S.speciosa* with 1.5 l of polyacrylamyde powder;
(3) isolated *S.arnottiana* with 1 l of polyacrylamyde powder; (4) isolated *S.arnottiana* with 1.5 l of polyacrylamyde powder. The results after two months of seeding show 60% of survival, and there are not significant differences between treatments.

(ii) Survival of *Prosopis denudans var. denudans*, *Grindelia chiloensis* and *Schinus johnstonii*. The treatments were:
(1) 0 l of polyacrylamyde powder;
(2) 2 l of polyacrylamyde powder;
(3) 2 l of polyacrylamyde powder + organic matter.
The results after two months indicate that the contribution of organic matter and polyacrylamyde powder increase the survival of the species (in *P. denudans var. denudans* (1) 20%, (2) 90%, (3) 98% averages; in *G. chiloensis* (1) 35%, (2) 87%, (3) 83% averages; in *S. johnstonii* (1) 8%, (2) 62%, (3) 75% averages).

(iii) Survival of *Prosopis denudans var. denudans*. The treatments were:
(1) 0 l of polyacrylamyde powder,
(2) 0.5 l of polyacrylamyde powder,
(3) 1 l of polyacrylamyde powder.
In each treatment, half of the plants were protected against the livestock. The results show that there are significant differences between treatments with polyacrylamyde powder, and without polyacrylamyde powder (95 and 2%) respectively. The mortality of treatments without protection was of 17% in the first 2 months of transplant.

In Aguada Pichana we evaluated:

(iv) Survival of *Acantholippia seriphioides*, *Senecio filaginoides var filaginoides* and *Poa ligularis*, through the transplant of mature plants with different volumes of polyacrylamyde powder (0, 2, and 3 liters). The results show that the survival of *A. seriphioides* was of 0% in all the treatments, for *P. ligularis* and *S. filaginoides var. filaginoides* were of 60% in all the treatments.

Conclusions

It is necessary to consider the heterogeneity of the vegetation in the planning and implementation of the restoration projects. In arid and semi-arid environments of the north of Patagonia, the reintroduction of native plants for rehabilitation is an important strategy. The moisturizing gel polyacrylamyde powder usage, allowed a higher survival percentage of the different species. As regards pioneer species in the succession as *S. arnottiana*, facilitation is not a fundamental factor for survival. It is recommended to protect against herbivores during the first stage of development in those species that are consumed by the livestock.

Recommendations for decision-making

A great vegetation heterogeneity is characteristic of the region, and is also found in small scale areas, and it is necessary to consider these differences previous to the rehabilitation works. The recovery of degraded areas with native species, moisturizing gel, or by the direct transplant of mature plants, is an alternative that offers a quick answer to degradation. It is fundamental to promote further investigations regarding restoration in Patagonia. It is important for the development of regional workshops to share with local people and technicians tools and knowledge that will enable them to incorporate the knowledge acquired in rehabilitation research.

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Land degradation through sediment movement from hillslopes disturbed by landscape fires: a pilot study in northwest Patagonia, Argentina

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Abstract: Landscape fires are a significant cause of land degradation in Argentina. Quantifying the post-fire loss of fertile soil through runoff and deflation is an important prerequisite to the official implementation of post-fire intervention protocols. A high-intensity fire affected 5,500 ha of mixed forest and shrubland in northwestern Patagonia, leaving 90% of mineral soil exposed to erosion by runoff. In this region, the lag time between the summer fire season and the winter rainy season favors early grass regeneration and soil stabilization. The greater erosion hazard is meltwater runoff in the spring.

Keywords: landscape fires, post-fire erosion, post-fire protocols, Patagonia

Introduction

Every year, an average of one million ha of forest-shrubland-grassland are lost to landscape fires in Argentina. In addition, the number of wildfires shows a steadily increasing trend (IFFN 2003). The loss of fertile soil from burned hillslopes and plains, and through runoff and deflation, is potentially a major problem in Argentina, affecting two fundamental pillars of its economy: agriculture and cattle raising. Nonetheless, little effort has gone into quantifying this loss and establishing post-fire intervention protocols. The National Fire Management Plan is concerned with techniques and protocols to combat wildfires but has not included post-fire consequences regarding soil movement and flood hazard. The project reported herein contributes to filling this gap.

'La Colision' landscape fire

In the austral summer of 2008, an intentional fire devastated 5,500 ha of mixed forest and shrubland in the Andean foothills of Chubut Province, in northwestern Patagonia. The fire ignited the hilltops at 900 to 1,200 m altitude (above sea level) and then, swept by strong winds, propagated rapidly downslope to the valley floor below 500 m altitude, overcrossing the moderate-sized Percey River in its course.

Mostly native tree species (Nothofagus and cypress) together with minor imported pine stands, make up the upper slopes, with canopy heights reaching 20 m. The lowlands are covered by grass and various shrubs. The soil is of volcanic origin, composed largely by medium to coarse sand grains. Precipitation (snow and rain) ranges from 300 mm/yr in the lowlands to 700 mm/yr in the highlands and is concentrated in the Austral winter months. The dry summers favor the initiation and propagation of wildfires.

The *'La Colision'* fire lasted seven days (February 24 to March 3), with fire intensity at high levels on 3 of those days. Tree foliage and the above-ground herbaceous stratum were completely burned in 80–90% of the affected area. Tree trunks and shrub stems larger than 2 cm in diameter were scarred but not entirely consumed. The humus layer was consumed but the root systems largely escaped burning. The average composite burn index yielded 2.4 (0 is unburned, 3 is consumed; USGS-NRMSC 2001). The mineral soil was left bare in 90% of the affected area. Thus, fire severity (related to damage to vegetation) was high and burn severity (related to damage to soil) was low to moderate.

Forty days after the fire, small debris flows were observed to have developed on steeper slopes, indicating high sediment mobility. On lower gradient slopes, incipient grass growth was observed. Sediment traps (design taken from Moody and Martin 2001) installed in April 2008 showed minor accumulation one year after the fire, however, suggesting their location may be off the major sediment paths. Additional silt fence traps have been deployed. In May 2008 a volcanic eruption deposited a layer of ash over the entire study area. This is an ongoing project; a more definitive sediment balance will be available in early September, after the snow melt, in time for the DSD Conference. These data will be contrasted with the results of modeling with the Revised Universal Soil Loss Equation and Water Erosion Prediction Project.

Conclusions

Preliminary results suggest that, in northwestern Patagonia, the lag between the summer fire season and the start of the winter rainfall favors stabilization of the soil by grass growth, before mantling by snowfall. Erosion by meltwater runoff in the spring remains as a major erosion hazard but has not yet been adequately quantified.

Recommendations for decision-making

Upon request of expert advice from CC Brockerhof, the National Fire Management Plan Regional Coordinator, this project recommended inclusion of post-fire protocols in the PNMF. To strengthen this position, the current project will convene a workshop to discuss details of post-fire protocol implementation and merging with existing National Fire Management Plan protocols.

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Monitoring vegetation changes under continuous sheep grazing in northeastern Patagonia

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Abstract: The grass or grass with scattered shrubs steppes of the Punta Ninfas area in northeastern Patagonia are ecosystems with a high production potential for sheep grazing. In many places, these have largely been replaced by shrub steppes and their soils have been eroded. Livestock grazing has been considered the main cause of these changes. In the autumn of 2003, five exclosures were established to assess the natural recovery of the degraded areas. In each exclosure as well as in an adjacent area, three fixed plots were established to assess changes in the perennial vegetation cover in each of three different states of a state-and-transition model: two stable states (a "functional" grass and a "dysfunctional" shrub steppe, respectively), and a transitional state. During the period 2003–2007, with annual rainfalls close to the long-term average, no changes in perennial vegetation cover were detected, either in the exclosure or in the grazed areas. However, by the end of 2008, a significant decrease in vegetation cover, mainly perennial grasses, was recorded at the end of the growing season in the three states of the grazed areas as compared to the exclosures. The extended drought (end of 2007–2008) would explain the decrease in perennial vegetation cover under grazing conditions.

Keywords: long-term monitoring, functional and dysfunctional ecosystems, drought, state-and-transition models

Introduction

Soil erosion and shrub encroachment have been identified as the main degradation processes of the arid and semi-arid ecosystems of Patagonia. This problem has led to recognition of the need for the assessment and monitoring of rangeland ecosystem in order to detect trends and improve management strategies. Ecosystem management and conservation are based on conceptual models (ie state-and-transition models) that represent our understanding of how and why ecosystems change over time and how different management actions are likely to affect them (Westoby et al. 1989; Bestelmeyer et al. 2003). Considering this premise, we used a state-and-transition model (Chartier and Rostagno 2006) to organize and communicate our understanding of the Punta Ninfas ecosystems. Based on this model, we defined a long-term monitoring program to assess the dynamic of the perennial vegetation of the different states under grazing and grazing-exclusion conditions.

Results

During the period 2003–2007, with annual rainfalls close to the long-term average (259 mm), no significant changes in perennial vegetation cover were detected, either in the exclosure or in the grazed areas. However, by the end of the growing season of the year 2008, a significant decrease in vegetation cover, mainly perennial grasses, was recorded in the three states of the grazed areas as compared to the exclosures. The extended drought (end of 2007–2008) would explain the decrease in perennial vegetation cover under grazing conditions.

Conclusions

In spite of a rest period of 6 years (the exclusion condition), the perennial vegetation cover of the transitional state, as defined in the state-and-transition model, did not increase. Under continuous grazing, the perennial vegetation cover decreased drastically in the last year in the 3 states. The extended drought (end of 2007–2008) would explain this decrease in perennial vegetation, a condition that may accelerate soil erosion. This slow dynamic of the perennial vegetation cover under grazing exclusion and its significant decrease during a dry year under grazing conditions highlights the need for long-term monitoring with at least a yearly frequency.

Recommendations for decision-making

Although we have good information on the location, severity and extent of the degradation of some Patagonian rangelands, decision makers as well as land managers need to know how the different ecosystems are changing (ie the trajectory of change in ecosystem structure and/or function over time) under different management schemes and how they can be affected by extended drought periods. To achieve this objective, we need to implement long-term monitoring programs specifically included in adaptive resource management plans. However, no institutional support exists for long-term programs. Perhaps the main recommendation for decision makers of the regional level with responsibilities in the control of desertification is to create the institutional conditions to implement long-term participatory assessment and monitoring programs.

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MARAS: a monitoring system for Patagonian rangelands

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Abstract: A monitoring system '*Monitores Ambientales para Regiones Aridas y Semiáridas*' (MARAS) is being installed in the Patagonian region. The system will assess the trend of rangelands under variable management practices on a regional basis and over a long time scale. It consists of 600 ground monitors assessed with a single methodology and deployed in 13 ecological regions and 31 landscape units, in different vegetation types from shrublands to grasslands. Data collected include ground cover, vegetation patch structure and stability and function of bare soil patches. It will also test for organic carbon, texture and other soil properties. The sites will be reassessed at 5-year intervals and data will be collated in a single online database that will be accessible to government decision makers, farmers and technical advisors. The system will assess the long-term effects of improved management of rangelands and the effect of climate change on these unique ecosystems.

Introduction

Cold semi-deserts in Patagonia remain mostly as unmodified rangelands stocked with about 9 million sheep, 0.8 million cattle and 0.8 million goats. The 75 million ha of land are subdivided in about 14,600 farms, mostly family enterprises, 56% of which have land property rights. The other producers have mostly small farms on some public lands, with a few nomadic people remaining in the north. Colonization of these areas started 120 years ago for sheep tending, but even today the total rural population is sparse, with only about 0.2 million people. Rangeland degradation is a concern for farmers and governments alike because global sheep numbers declined from 20 million in the late 1980s to less than half that currently. The reasons for the decline include economic problems, but most troubling are declining production indexes derived from range deterioration. Evaluations have shown that about 30% of the area is in under severe desertification. Range evaluation strategies were developed in the late 1980s and applied extensively in the area (Borrelli and Oliva 2001b, Borrelli and Oliva 2001a, Elissalde et al. 2002). The basic assumption of the derived management plans is that no undesirable transitions in the rangelands would occur if overgrazing of main forage species is avoided. In some areas, annual monitoring of forage biomass and residue height is done, but no single methodology for long-scale assessment of soil and vegetation trends is in place. Furthermore, climate change is anticipated and is challenging the assumption of an equilibrium between grazing and range regeneration processes.

Body of work

In the GEF/UNDP 07/35 progamme, a combination of extensive rangeland technology (TME) (Borrelli and Oliva 2001b) is promoted with a monitoring system named *Monitores Ambientales de Regiones Aridas y Semiáridas* (MARAS) (Oliva et al. 2006). This system consists in a network of ground monitors that allow for repeated evaluation of early indicators of rangeland conditions, including ground cover (point quadrant line), patch structure (Canfield lines) and soil patch stability and function analysis (adapted land function analysis). The methods have been adapted from Australian (Tongway and Hindley 2004), USDA/Jornada (Herrick et al. 2005) and regional monitoring methods used in Patagonia. Both methodology and field registration forms have been discussed by rangeland scientists of different INTA stations along the region and adopted in six state governments. The complete system will include 600 monitors distributed on 14 ecological regions that encompass 31 Great Landscape Units and different vegetation types, ranging from shrublands to grasslands. The number of monitors will be proportional to the area representation of each ecological and landscape unit. The timeframe for reassessment is in 5-year periods, and the full system will be gradually deployed and the installation finished by 2011.

Conclusions

The initial 60 monitors of the system have shown that the methodology can be implemented in different vegetation types, and that typically a team of four people is able to install one monitor per day, including travel and producer interviewing. The support of GEF/UNDP 07/35 will be used to finish the installation phase.

Recommendations for decision-making

At present, about 10% of the monitors have been installed and the data are still in paper and worksheet formats, but an open-source database is being developed to store the data and this software will be available as stand-alone programs for field data collecting. These programs will be able to connect with a central database, accessible to decision makers through web browsers. The system will be able to draw key indicators such as vegetation cover, diversity, invasive species, shrub encroachment, soil carbon, soil stability and patch structure, which will be important to further orient resource management policies in these unique rangeland ecosystems under changing climatic, economic and social demands.

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Seasonal and inter-annual fluctuations of vegetation in landscape units in central Patagonia

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Abstract: The fluctuations of environmental conditions and their consequences in the ecosystems or landscape units, taking into account the vegetation of the semi-arid zones in San Jorge Gulf Region in Central Patagonia, were analyzed in this work. The variability of the environmental conditions influences the phenology of the vegetation, mainly through changes in the soil moisture and the temperature. Although the relationship between climatic fluctuations and the vegetation at global and regional scale has been discussed in the literature, there is a paucity of research at local scale. Knowledge of long-term processes and landcape units monitoring from satellite images and field samples of natural resources constitutes an essential tool for ecosystems conservation and range management planning.

Keywords: landscape units, remote sensing, long-term monitoring, range management

Introduction

Vegetation monitoring from satellite images constitutes an essential tool for the conservation of the ecosystems and the planning of the productive units. The analysis of the Normalized Difference of Vegetation Index (NDVI), based on high-resolution satellites (Landsat 5 TM and Landsat 7 ETM+) provided by Comisión Nacional de Actividades Espaciales from Argentina, allows the approach between the biological and meteorological variables in several space and temporal scales. Among the climatic variables, annual and seasonal precipitation are determining of the productivity of the natural ecosystems of arid and semi-arid zones, and other variables as the temperature and the speed and wind direction also have effects on the structure and dynamics of the vegetation in this type of environment.

Body of work

The NDVI can be related to biophysics variables such as the Index of the Foliar Area, vegetal cover, primary productivity, as well as the phenology of the vegetation. The vegetation index in the 2001–2008 period in landscape units was analyzed to obtain a predictive model of primary production and monitoring of the biological changes due to environmental conditions. The landscape units, which were named 'geosystems' and 'geocomplexes', were defined in a 4,000 km^2 area in the San Jorge Gulf Region, based on topography, geomorphology, vegetation types and climatic conditions. An unsupervised classification was developed to define 9 principal classes organized from low to high NDVI values. Changes of biological variables and primary production were evaluated at the landscape units. A classification between landscape units and classes was developed in order to establish the landscape degradation level and the potential use of the units. A lineal model of the 2001–2008 period was developed for vegetation cover and primary production, taking into account the climatic conditions.

Conclusions

The database created in the San Jorge Gulf Region in Patagonia Central was established in 2001 to contain field, meteorological and remote sensing data over the long term. The definition of landscape units at geosystems and geocomplexes levels allowed the establishment of a referenced database from which it is feasible to conduct temporal monitoring. The primary production model allows adequate grazing according to the carrying capacity of Patagonian steppes and grasslands.

Recommendations for decision-making

The main objective of the present project is contribute to the range management and regional planning and create synergy among farmers and university to prevention and control of desertification processes in the San Jorge Gulf region as a consequence of sheep overgrazing.

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Regionalization criteria for sustainable land management and assessment in Catamarca, Argentina

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Abstract: Access to water for domestic consumption and productive purposes is a common constraint to rural development in Catamarca Province. A lack of conservation policies for sustainable cattle management practices impacts negatively on the water cycle, overall productivity and population. There are a large number of local examples which illustrate this problem and the obvious weakness in the development of operational criteria for the regional analysis and for the development of polices for watershed observation planning. This work shows the ability of simple quantitative spatially distributed hydro and geomorphologic methodology to detect limitations to water access by the rural population, and to develop tools for soil and water conservation planning and thematic cartography.

Keywords: Groundwater, land degradation, geomorphology, rural population

Introduction

In the Catamarca province, Argentina, groundwater is the most popular source of water used by the rural population. Diffuse water outcrops (locally named *'vertientes'*) or springs are used for domestic consumption and productive purposes. The problems associated with the spatial and temporal evolution of the quantity and quality of such water sources are the main limitations for the survival and sustainable development of these populations. On the other hand, current processes of land degradation affect the hydrological response of the different catchments basins and their overall sustainability. Hence, this environmental degradation has an affect on dispersed rural populations' access to safe water sources.

Body of work

The region of interest is located in the center and eastern sector of the Catamarca Province. This region includes four administrative territories: Ancasti, El Alto, Paclín and Ambato shires (*'departamentos'*). Substantial field evidence of land degradation can be observed in the area. Current cattle management practices compromise the sustainability of watersheds by reducing soils' infiltration capacity and degradation of pasture lands, which in turn is a significant contributing factor for erosion. In order to carry out this study, the easternmost administrative territory (the Ancasti shire) was chosen as a sampling area.

Based on available topographic data, field observation and exploratory fieldwork with rural communities, two different analyses were performed. Firstly, available topographical information (Digital Elevation Model, provided by the Shuttle Radar Topography at: http://srtm.usgs.gov) was used to perform a quantitative spatially distributed hydrologic and geomorphologic analysis based on the ideas developed by Beven and Kirkby (1979) and exposed in Gyasi-Agyei et al. (1996) Digman (2002), and Reid et al. 2007) for modeling the hydrological response of contributing sub-areas in a catchment basin. Additionally, filed work was carried out to analyze the degree of difficulty of accessing water sources that satisfy domestic and productive needs throughout the year. This work was developed in 33 localities within the sampling area, covering the most common water issues in the region. Significant correlations were observed after combined analysis of these two studies. These provide a quantitative explanation of the association between the degree of difficulty in accessing a water source and the location of the community within a region and a watershed. Furthermore, geomorphologic criteria allowed the identification of the degree of susceptibility of terrain located in the studied areas in relation to the land degradation evidence observed during field observations.

Conclusions

There is a significant relationship between the spatial distribution of areas of different hydrological behavior shown by the Beven and Kirkby (1979) criteria and the degree of difficulty in accessing a water source that satisfies the domestic and productive requirements throughout the year. Furthermore, the catchment areas where infiltration processes play a fundamental role and the most affected areas by land degradation processes can be accurately identified by using a simple quantitative spatially distributed hydro and geomorphologic methodology.

Recommendations for decision-making

Actual land degradation problems need quantitative and spatially distributed tools in order to find real solutions. Applying conventional technical procedures only allows having a limited set of local data referred to the problem. Consequently, it is very difficult to evaluate the real impact degree of land degradation processes and its consequences for this issue. The lack of quantitative distributed evaluation criteria for the area of influence is the main reason for the absence of policies to guarantee its sustainable rural development. Simple quantitative spatially distributed hydro and geomorphologic methodology could determine a substantial improvement in this matter. This methodology has a significant impact on the investigation and quantification of the different areas as well as in the spatial distribution of hydrological and degradation processes. Consequently, it is possible to apply simple and operative regionalization criteria for sustainable land management and assessment.

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Monitoring station for wind erosion in the southwest of Buenos Aires province

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Abstract: Wind erosion is one of the most important processes of degradation of soils in the semi-arid region of Argentina. Within this region, the southwest of the Buenos Aires province is the zone most affected by this problem. It is known that science and technology can give valuable information to revert this phenomenon. With this criterion, the Unidad de Manejo y Conservación de Suelos of the Universidad Nacional del Sur has set up a monitoring station and evaluation of wind erosion. It has an automatic weather station and dust samplers (BSNE, BOSTRA, superficial catcher). The objective is to measure real soil loss in a continuous form in time and related to different conditions of management of land and climate. At the same time, there are forecasts of wind erosion by the models WEQ, RWEQ and WEPS. Later models will be validated according to their accuracy and functionality. In this way, the selected models will help plan the most sustainable land management.

Keywords: Buenos Aires, wind erosion measuring, wind erosion models, dust samplers

Introduction

It is estimated that about 60 million ha in Argentina, 20% of its territory, are affected by wind and water erosion (PROSA 1988). The wind erosion affects basically the semi-arid region where it is located the southwest of Buenos Aires province. The Patagones, Villarino, Puán and Bahía Blanca districts are the most affected ones, owing to frequent droughts resulting from scarce rain and persistence of strong winds. The wind erosion degrades the soil in an irreversible way (Buschiazzo and Taylor 1993), modifies the humification and diminishes the rate of organic matter accumulation (Buschiazzo and Aimar 2003) and the chemical fertility of the soil (Lyles and Tatarko 1986). The main direct causes are overgrazing, the inadequate use the farming tools and the tillage of lands without agriculture capacity (Casas 1998). Wind erosion reduces productivity and endangers the sustainability of the farming systems (Silenzi et al. 1994).

Body of work

The Unidad de Conservación y Manejo de Suelos, as part of a research project, is evaluating wind erosion in different situations of use and soil management for real weather conditions. In order to do it, at a distance of 28 km from Bahía Blanca, in the experimental field of the Agronomy Department, Ministerio de Asuntos Agrarios de Buenos Aires (coordinates 38°.445 – 62°28W), a monitoring unit has been installed. It has an automatic weather station (Davis Vantage-Pro) equipped to measure temperature, solar radiation, precipitation, humidity, barometric pressure, and wind speed and direction. In addition, three kinds of dust samplers have been installed: BSNE, BOSTRA and a superficial catcher, designed to capture suspension, saltation and surface creep soil particles.

Conclusions

On completion of the monitoring unit, isolated events of wind erosion have been evaluated in a soil classified as Entic Haplustoll. Eroded soil measured with rotary sieve was high (I = 240 t/ha/year). The wind measure indicated that erosive winds flew from north and northwest with maximum speed of 75 km per hour. The longest storm lasted 22 hours. Wind erosion was measured in two conditions: V=1.00 (without surface cover) and with little surface roughness (K = 0.90–0.95) and V=0.70 (with a little surface cover) and little surface roughness (K = 0.90–0.95). Preliminary results indicate that the soil in the condition V=1.00 doubled the soil loss with respect to V=0.70. In both situations, the most important movement of soil particles was found between the surface and 30 cm high.

Recommendations for decision-making

In the short term, the use of conservation tillage with a surface cover of 30% must be promoted, or in its absence, systems that leave rough soil, such as chisel tillage. In the long term, in addition to tillage practices, work must be done on crop rotation to increase the levels of organic matter of the soil and improve the soil structure. In soils that more liable to suffer wind erosion, there must be permanent pastures that do not require soil removal every year, as well as windbreaks.

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The cost of wind erosion in the southwest of Buenos Aires province

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Abstract: The investigations on wind erosion by the Unidad de Conservación y Manejo de Suelos indicated that the loss of a centimeter of the soil in the southwest of Buenos Aires produces an average reduction in the yield of wheat of 50 kilograms per ha. Out of 3,161,403 ha that are used for wheat cropping, 639,717 ha presented a historic loss of about 10 cm of soil. As a consequence, the annual reduction in the wheat yield is an average of 320,000 tons, equal to over $51 million. Within this framework the Patagones District stands out with 153,608 affected ha by wind erosion of the 222,620 ha under wheat cropping, with an estimated annual loss of more than $12,000,000. As a consequence of the process of wind erosion and strong droughts of the last years, the Patagones District shows a widespread process of desertification as rural families abandon the countryside and migrate to towns.

Keywords: Buenos Aires, wind erosion, eroded soil, wheat yield

Introduction

Wind erosion is the result of an inadequate link between man and land. In the process there is a direct relationship of cause and effect, as the yields show that eroded soils produce less than a non-eroded soil, while the production costs are the same or higher.

The economy of the southwest of the province of Buenos Aires is based, to a great extent, in wheat production. The official registers show that the amount of wheat harvested in the last 5 years was over 13 million tons, which represented 32% of total crop production in the province. A major part of the economy of the region relies on the fertility of its land, which is reduced by anthropogenic wind erosion. This process seems to worsen due to recent droughts. The objective was to assess the loss of wheat production in the southwest of the province of Buenos Aires, as a consequence of wind erosion loss of soil.

Body of work

The results of the investigations show that the Patagones District harvests 222,620 ha of wheat in average, per year; of this area 153,608 ha (69%) present wind erosion with a loss of yield of 76,804 tons, representing US$12,288,640.

On the other hand, the Villarino District harvests an average of 110,480 ha per year; of this area 75,126 ha (68%) present wind erosion, with a loss of yield of 37,563 tons, representing US$6,010,080.

The Puán District harvests an average of 120,260 ha of wheat per year; of this area 69,751 ha (69%) present wind erosion, with a loss of yield of 34,875 tons, representing US$5,580,000.

The Coronel Dorrego District harvests an average of 234,138 ha of wheat per year; of this area 65,559 ha (28%) present wind erosion, with a loss of yield of 32,779 tons, representing US$5,244,640.

The Adolfo Alsina District harvests an average of 92,380 ha per year; of this area 58,199 ha (63%) present wind erosion, with a loss of yield of 29,100 tons, representing US$4,656,000.

The Saavedra District harvests an average of 92,570 ha of wheat per year; of this area 56,468 ha (61%) present wind erosion, with a loss of yield of 28,234 tons, representing US$4,517,440.

The Bahía Blanca District harvests an average of 46,000 ha of wheat per year; of this area 37,720 ha (82%) present wind erosion, with a loss of yield of 18,860 tons, representing US$3,017,600.

The other districts (Güaminí; Tornquist; Coronel Rosales; Coronel Pringles; Coronel Suárez) altogether harvest 415,005 ha of wheat per year; of this area 123,286 ha present wind erosion with a loss of yield of 61,644 tons, representing US$9,863,040.

Conclusions

The southwest of the province of Buenos Aires harvests per year 1,333,453 wheat ha, with an average yield of 2,689,398 tons. Of the above-mentioned regions, 639,717 (48%) present loss of soil by anthropogenic wind erosion, in moderate to severe grade. As a consequence, wheat production is reduced in 319,859 wheat tons, which expressed in economic terms means a loss of US$51,177,440 per year. Owing to degradation and to the great drought of the last years, more and more desert areas are appearing in the most affected districts. In this context, a lot of farmers in Patagones who are not gaining enough profit have abandoned the countryside and emigrated to the nearest towns.

Recommendations for decision-making

The soil degradation provoked by wind erosion in the southwest of the province of Buenos Aires is a very complex problem; therefore it requires solutions planned with criterion and knowledge. In addition to the climatic aspects, there are social, economic technological and political causes. The size of fields, land ownership, prices of products, tradition and customs, lack of knowledge, lack of technological development, policies of investigation and of investment, are aspects that have great impact on soil degradation.

There must be an integral work on these aspects; in this sense, it is necessary to have a strong political decision by the State. Universities and official institutions have professional men and women trained to work in an integral plan.

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Desertification, climate change and land use in Argentine Puna region since 1975

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Abstract: Puna region is a geotropic dryland extended in four countries: Argentina, Chile, Bolivia and Perú in the southern portion of the arid diagonal section of Latin America. It provides ecosystem services and supports human populations, which in some cases degrade the land resources with unsustainable land use. It is a cool semi-arid steppe at very high elevation (3,700 m to 4,500 m above sea level) and occupies approximately 1,100,000 km^2. It is located between 22–25 degrees south latitude and 65–67 degrees west longitude in the Argentine Puna region. The vegetation is characterized by tall tussocks of bunchgrass and other grasses, shrubs like *Parasthrephia lepydophilla*, cushion plants and sparse lichens, mosses, and ferns and herbs.

Intoduction

Several factors and processes contribute to land degradation and desertification in the Puna area. This problem decreases land productivity. In this region there are logistical difficulties in obtaining ground data quickly and with an appropriate level of accuracy.

Transhumance pastoralists follow a cyclical pattern of migrations between highland valleys in the summer and lowlands in the winter. Overgrazing in either system may cause human-induced desertification and clearance of woody vegetation. In the last 9 years, the main land use is grazing of llamas, alpacas, goats and sheep but since 1975 cows, sheep and goats were the main domestic livestock that contributed to overgrazing. They caused destruction of fragile soil structures, leading to water and wind erosion. A dry period originated in the La Niña phenomena increased the risk of soil erosion by wind and water. Urban industrial mining occupation started in ancient times, as these regions were part of the Inca Empire; a network of roads stretched through the region, forming the *Qhapaq ñan*, popularly known as *Camino del Inca*. Desert wetlands are very important not only as sources of food for wild and domestic animals, but also as water reservoirs. In Puna, the shepherds build *pirca* (stone enclosures) around a *vega* to manage their livestock's grazing. Erosion by wind and water are often linked – when seasonal rains follow long dry periods and very erosive flash foods deposit sediments that are easily affected by wind erosion. Wetlands under sustainable use have more vegetation and less salinization in recent years.

Body of work

The aim of this study was to determine the trend and the link between land degradation, climate change and land use since 1975 in Miraflores river basin, Argentine Puna.

Vegetation cover, wind erosion, water erosion, salinization, animal pressures and human pressures were measured since 1975, based on the guidelines issued by the FAO for the gathering of field data.

As degradation in general and especially in drylands (desertification) is difficult to measure with any level of precision, since 1995 an adaptation of a method suggested by Navone et al. (2004) was used. Field data were taken in the sample areas, representative of each landscape. Each landscape has different land use and management. Since the launch of the LADA project in 2006, we have sampled areas with different human pressure and management which are called hot and bright areas. In those areas we are still monitoring desertification following the LADA approach.

Important changes in both rainfall and temperature have taken place in this region due to El Niño southern oscillation and La Niña events, with subsequent growth conditions. Rainfall shows differences of 160 mm/year between El Niño and La Niña years. Greater changes due to climate change are predicted by the IPCC studies and reports of nine different models: change in mean precipitation of 0.25 mm/day and an increase in 3 or 4 degrees in mean temperature (Bates et al. 2008).

The increase of rain and temperature promotes vegetation changes in composition, followed by an increase in the number and types of animals (in other words, changes in land use). The results obtained in 1975, 1993, 1997 and 2006 show two different relations between the principal processes involved in desertification (area affected by wind and water erosion and variation in vegetation cover), rainfall and land use. There is a correlation of 0.66 with rainfall and a correlation of 0.78 with different land use and management. While the relation with the rainfall is constant along the basin, the correlation with land use varies from 0.66 up to 0.8, according to the landscape.

Conclusions

Changes in rainfall and temperature due to climate change, and to the El Niño southern oscillation phenomena, generate important variations in vegetation. The economic situation in the country and especially in urban areas promotes an increase of livestock and population in this dry basin. Without sustainable management, these changes could increase the rate of desertification as it can be seen in the correlations shown above.

Recommendations for decision-makers

These changes in a fragile ecosystem call for us to be very careful. The balance is unstable, and any change in the climatic pulse or an inadequate management will cause irreversible desertification, which will immediately affect the food security and livehood of the population in Puna and in the arid northwest valley. This is the reason why decision makers should understand this ecosystem and decisions can and should be made based in serious models, generated by systematic researches along decades. Decisions must not be taken based on occasional economic situations or on short-term studies. The challenge remains to protect not only local but regional natural resources, and to develop a viable future for the people living in Puna, where environmental conservation and economic development must be achieved.

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Impact of livestock on desertification in the Rio Miraflores Basin, Jujuy, Argentina

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Abstract: Since the arrival of the Spaniards and the introduction of sheep, goats and cattle, the impacts on this low-resilience ecosystem have increased. The introduction of alien grasses such as *Eragrostis curvula* (weeping grass) and the use of fencing have favored the increase of livestock numbers, especially cattle (Census INDEC 1990), with consequent overgrazing (Bertuche and Vorano 1977). This pressure has led to the emergence of increasingly severe manifestations of land degradation and desertification (Vargas Gil 1980).

Introduction

The objective of this project was to evaluate the impact on vegetation and soils produced by sheep, goat and camelid grazing, and the associated increased vulnerability to desertification.

Body of work

We analyzed a sector of the river Miraflores basin, in Abra Pampa (65°30 W and 22°45 S). It is a typical pocket Puno at 3,800 m altitude (above sea level) with a surface of 230,000 km^2, representative of wide sectors of the Argentinean Puna. Plain and foothill environments with *Torriortentes tapto argico* soils and a cover of *Fabiana* (*tola*) and *Baccharis boliviensis* (*Chijua*) were evaluated. (Vorano and Vargas Gil 2002; Ruthzatz and Movia 1975). The effect of grazing on cover and status of vegetation was measured in this area, in two observation dates at the beginning and end of summer season (November and March), a period when the highest rainfall occurs (360 mm and 380 mm annual rainfall, respectively) and the greatest development of vegetation is registered. These measurements were performed in 2 consecutive years. Indicators of physical degradation and water and wind erosion were measured.

Animals (llama, sheep and goats) were taken from reference groups (30 to 40 animals) belonging to different shepherds' settlements in the mentioned environments. The number of cattle was too small to be evaluated.

The main results were that goats ate and damaged the branches of shrubs, provoking a land cover decrease of 12%, both in leaf area and in the survival of the scrubs in the second year. Persisted scrubs also suffered the abrasive action of sand moved by wind erosion. Sheep caused a decrease in surface coverage primarily of grasses as well as scrubs, both reducing in a 10% the original cover in the second year. Llamas (*Lama glama*) produced no significant changes in vegetation cover. These results point out that overgrazing by sheep and goats is the main causes of land cover decrease, which is an indicator of overgrazing.

Changes in the period under review did nor produce significant changes in the processes of degradation but justify the state of degradation of the units reported by mapping (Navone 1995).

Another desertification indicator was analyzed: the quantity of animals (through 1988 Agriculture National Census and 1997 National Survey of Agriculture). The two sources revealed a 6.78% decrease of the existence of sheep, a 8.9% decrease of goats, and that the native camelids decreased by 22.58%. Cattle, with only 10,702 animals, have increased since 1988 by 12.4%.

Conclusions

Sheep and goats induced a decrease in the percentage of vegetation cover, an indicator of overgrazing, while camelids did not affect it. The decrease in the number of sheep, goats and camelids was an indicator that showed the responsiveness of the system to degradation. Both indicators showed that this type of livestock management leads to desertification.

Recommendations

Encourage the raising of camelids as livestock, leaving only a small number of sheep, goats and cattle for household use on established plots under proper management. It is necessary to encourage institutions engaged in plant genetic improvement to select native grasses to improve local pastures.

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Poster sessions

IV. Thematic / cross-regional

Results of the second worldwide user survey of LADA project

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Abstract: A worldwide user survey was conducted on behalf of the Land Degradation Assessment in Drylands (LADA) project for the period 10 May – 10 June 2009. The purpose of the survey was to determine the reaction to the kind of features and information that stakeholders had considered useful in a land degradation information center as implemented at the LADA website. Approximately 200 hundred stakeholders from United Nations agencies, international organizations, NGOs, the private sector, government offices and the research/education community were contacted; 150 responded. The last category was the most active in the survey, accounting for 69% of respondents.

Survey results indicate that the overwhelming majority of stakeholders are very interested to have information on indicators and their practical use for land degradation/desertification assessment and monitoring, followed by the need for methodologies to assess and evaluate land degradation intensity. The need for maps and databases on land degradation is the third priority, while land use policies and sustainable land management to prevent loss of productive lands ranks fourth in the priority list of land degradation/ desertification commitments. The information exchange between all stakeholders was seen as an urgent need to fill the gaps in flow of knowledge, and the upscaling and downscaling of research results was considered as a possible remedy for this.

The survey indicates the needs for practical solutions to land degradation/desertification problems and the promotion of awareness campaigns at various levels. Seventy percent of the surveyees considered the establishment of regional LADA training centers to be of high priority so that LADA case study experiences could be replicated. Fifty two percent were satisfied at how LADA responds to land degradation/ desertification concerns; 95.7% were pleased with the information they find on the LADA website. Less than half thought that land degradation/desertification are recognized as major environmental problems in their countries but the political will to deal with them is still lacking. More than 80% thought that the National Actions Plans to Combat Desertification are not being implemented successfully despite the fact that 42% say that land degradation/desertification is part of the training programs and curricula at various levels of education in their respective countries. Stakeholders put special attention to the development of coherent policies and establishment of competent institutions for endorsement of effective actions.

Keywords: land degradation assessment, LADA, policy-making, sustainable land management, knowledge exchange

Introduction

The LADA project develops tools and methods to assess and quantify the nature, extent, severity and impacts of land degradation on dryland ecosystems, watersheds and river basins, carbon storage and biological diversity at a range of spatial and temporal scales (Nachtergaele and Petri 2008). It also builds the national, regional and international capacity to analyze, design, plan and implement interventions to mitigate land degradation and support sustainable land management practices. The project contributes to both environmental goals promoted by the UNEP and GEF as well as desertification/development objectives supported by the UNCCD and other UN multi-lateral agencies. The FAO is the executing agency for the project that runs for the period 2006–2010.

LADA follows a participatory, decentralized, country-driven and integrated approach and makes ample use of participatory rural appraisals, expert assessments, field measurements, remote sensing, geographic information systems, modeling and other modern means of data generation and processing, networking and communication technologies for sharing of information at national and international levels. The proposed approach aims to develop a methodological framework, rather than a rigid method. It is expected that the framework would give enough flexibility in terms of the procedures, techniques and state of the databases to accommodate the particular circumstances of the country or region where it is applied. The methodology is designed to be able to accommodate new information that will come in the future with the development of studies and advancement of technology. The LADA approach is being tested in Argentina, China, Cuba, Senegal, South Africa and Tunisia. LADA aims to establish a long-term assessment methodology and a global monitoring system to be able to trace changes in land degradation status and support sustainable land management decisions at local, regional and global levels.

Body of work

A special questionnaire containing 34 questions was sent to more than 200 stakeholders worldwide to explore the functionality of the LADA web page, of the project in general, to establish trends in land degradation/desertification commitments and to propose the necessary policy recommendations. The platform structure for conducting the survey used an easy-to-use electronic stand able to make statistical analyses. The majority of the surveyees who replied represent the researcher/education category (69%), followed by Government officials (both local and national), international organizations, the UN, non-governmental organizations and the private sector altogether covering the rest. Soil and desertification topics are the main areas of expertise of those who replied.

In contrast with the results of a previous survey on LADA (Zdruli 2007) that identified the "Integrated ecosystem/natural resources management" as the key priority when dealing with land degradation/desertification, results of this second survey indicate that stakeholders are more interested to know the trends of land degradation/desertification through the use of well-defined indicators. They place as second priority the endorsement of practical solutions for land degradation mitigation, followed by the necessity for a major focus on sustainable land management and for a better match between methodologies and technologies to combat land degradation/desertification. Other important issues are the linkages between land degradation, poverty, climate change and loss of biodiversity, as 67% of the respondents place this as high priority. Information exchange between all stakeholders ranks first when people are asked about the type of knowledge management they consider most important.

Conclusions

Capacity, policy and institutional building priorities indicate upscaling and downscaling of research results and enhancement of knowledge transfer for proper decision-making as top priorities, followed by the inclusion of the land value and ecosystem services into the national financial accounting systems. Additionally, importance is placed at endorsement of coherent policies and setting up of competent institutions able to implement effective actions "on the ground". It is concerning that more than 80% of the stakeholders think that the National Actions Plans to Combat Desertification are not being implemented successfully, despite the fact that 42% say that land degradation/desertification is part of the training programs and curricula at various levels of education in their respective countries.

Recommendations for decision-making

LADA could play an important role to promote wider application of assessment methods and tools for land degradation mitigation through the establishment of regional LADA training centers (agreed by 70% of the respondents). Their main scope could be the replication and dissemination of existing case study results.

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Progress on desertification assessment: the DeSurvey project

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Abstract: DeSurvey is an EU research project that intends to offer a solution to desertification diagnosis and monitoring. It integrates a flexible suite of tools, the technical content of which is summarized and has been already completed. The system is being implemented in several countries to increase their capacity to deal with desertification surveillance at high levels of performance, reliability and cost efficiency. To this purpose, a set of interfacing and training activities are being carried out to meet policy needs and help the system's application.

Keywords: desertification surveillance, land degradation, early warning, capacity building

Introduction

Designing effective mitigation actions for desertification requires reliable instruments to provide information about its triggers, the condition of the resources and the vulnerability of threatened land use systems. DeSurvey aims to develop a prototype of a multi-scale, cost efficient and flexible surveillance system to provide land managers and policy makers with early warning and monitoring capacity to enable decisions before irreversible desertification impacts occur. To this aim, tools are being developed and tailored to the requirements of potential user organizations like the EU and the FAO, the authorities for the National Plans of the UNCCD and local consortia of stakeholders in risk-affected countries.

Body of work

A feedback loop between bio-physical and socio-economic drivers is the keystone for integrating the surveillance system and its three main tools in a dynamic way to (i) assess the vulnerability of the threatened land use systems to desertification; (ii) monitor disturbance impacts and effects of mitigation programs; and (iii) conduct medium-term forecasting of land degradation across space under several climatic/economic scenarios. The three are self-contained and can be used independently to acquire information about either only one, two or the three facets of the desertification status and trend, as to enable a wider perspective of the phenomenon. The implementation of the tools in a set of countries and regions (South EU, Maghreb, Senegal, China and Chile) allows a better definition of their range of application and their complementarity.

Vulnerability assessment (Ibañez et al. 2008; Hellden 2008) is the lowest in data requirements and the highest in flexibility to cope with local conditions. Its strength is in the long-term time scale. It may be considered as preliminary screening tool to identify the most dangerous and non-sustainable land use systems. It has actually been applied to inland irrigated agriculture in Central Spain, the grazing systems of Northern Greece and some oases in Southern Morocco. In these three cases, the importance of the opportunity costs as alternative option to non-sustainable land uses has been stressed. Applications for Senegal, Chile and northern China are being implemented.

The monitoring tool has been applied to the Iberian Peninsula (del Barrio 2008; Roeder and Hill 2008) and it is being implemented in the Maghrebian countries, northern Senegal, northern China and in Central Chile (La Serena). It combines the identification and mapping of desertification syndromes with land degradation assessment across space including its current status and its short-term trend. The first Iberian application experience outlines the extent of geological and inherited land degradation from past desertification episodes, and the greening effect of agricultural abandonment in the more humid northwestern half of the peninsula.

Medium-term desertification forecasting is also being run in the Iberian peninsula, Italy and Tunisia. It provides a spatial display of downscaled economic and climatic desertification drivers, and their combined impact in terms of key use selected indicators, such as soil erosion rates, demographic parameters, land use changes or water balances. In this way it is possible to explore the trajectories across space of current or hypothetical conditions. In that context, it has been shown that the impact of changes in the regional and national agricultural policies or the eruption of new demands of agricultural products, such as in the case of biofuels expansion, are crucial as land degradation triggers.

Conclusions

It is still early to have strong conclusions, but the results obtained so far allow definition of the complementarity between the three tools. The monitoring procedure is very precise for the past and short-terms trend, while vulnerability assessment is most precise in scenario analysis, and medium-term forecasting finds its appropriate application at intermediate time spans – although its bigger data requirements may hamper its application in some countries. The inclusion of a dynamic component in the assessment substantially enhances the interpretability and the application scope of the results.

Recommendations for decision-making

Historically most drylands have been managed as grazing grounds with high mobility and low infrastructural investment. In this way, they developed resilience to environmental changes such as drought. Policy decisions involving agricultural encroachment, subsidies to stock breeding and sedentarization should be extremely careful at evaluating their impact on increasing vulnerability by using procedures like those developed by DeSurvey.

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Earth observation from space to support the UNCCD: the DesertWatch project

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Abstract: The goal of the DesertWatch project of the European Space Agency was to develop an Information System for assessing and monitoring land degradation using space-based Earth Observation technologies in order to support national authorities in their reporting to the UNCCD. The project has selected the most robust and reliable methodologies developed during related research projects, integrating them into a unique system which is easy to use, as automatic as possible and cost effective. The system outputs consist of a series of desertification indicators and products, generated at regional, national and sub-national scales. For demonstration purposes, these products have been implemented over large areas of Portugal, Italy and Turkey for the years 1984, 1994 and 2004. The validation phase has shown that the results are in line with user requirements. The possibility of expanding the system in countries outside the Annex IV UNCCD regional area is the subject of an extension to the project.

Keywords: long-term monitoring, land degradation, capacity building, information management

Introduction

Desertification is defined by the UNCCD as "land degradation in the arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities" (UNCCD 1994). In the Northern Mediterranean, 99.4 million ha show signs of desertification, corresponding to about 32% of territory with arid, semi-arid and dry sub-humid climate (UNCCD 2000). The European Space Agency launched in 2004 the DesertWatch project, whose requirements have been defined in collaboration with North Mediterranean National Focal Points of the UNCCD (Portugal, Italy and Turkey). DesertWatch exploits the potential of Earth Observation technology for desertification monitoring, building an information system aimed at supporting the UNCCD and the Parties.

Body of work

The main objective of the project was to monitor desertification at various scales and through time, developing an information system that can be operationally adopted by national and local authorities for reporting to the UNCCD and for local rules and policy development. The system was meant to be easy to use, as automatic as possible and, most importantly, to minimize the need for costly input data.

Many past and ongoing national and European research projects, such as MODULUS, MEDALUS, LADAMER, GeoRange, DeSurvey and RIADE combined Earth Observation and field data for monitoring land degradation at the regional level. The DesertWatch Information System is based on those research results, in particular on the commonly accepted MEDALUS approach, which integrates into a holistic view bio-physical, socio-economic and management parameters to identify environmentally sensitive areas to desertification. The DesertWatch Information System adapted this MEDALUS approach to compose a mainly Earth Observation-based system, which is a standardized, robust, reporting-oriented, and user-friendly tool.

Monitoring desertification extent requires the evaluation of a complex set of indicators, related to climatic, bio-physical, socio-economic and management factors (Enne and Zucca 2000). The mentioned MEDALUS approach identifies environmentally sensitive areas through the definition of climate, vegetation, soil and management quality indexes (Kosmas et al. 1999). Some of these indexes can be successfully assessed exploiting remote sensing technologies and geomatic applications (Hill and Peter 1996; Boer and Puigdefabregas 2005). The DesertWatch Information System uses primarily Earth Observation data in combination with some ancillary data, into a seamless data processing facility. To assess the needed indexes, the following principal approaches/techniques were used: land cover mapping, spectral mixture analysis, land degradation index assessment and spatial dynamic modeling.

Conclusions

The obtained results are in line with requirements defined by the National Focal Points. The quality of input data, including ancillary data, influences the final results: the flexibility of the DesertWatch Information System permits users to update the products in terms of frequency, producing new information at low cost, and in terms of quality, using better ancillary data as they become available. The expressed level of satisfaction for the system, maps and indicators produced has been very high. The DesertWatch Information System has been installed in the three participating countries and is routinely used to report desertification trends.

Recommendations for decision-making

An extension of the DesertWatch project to other European countries has just started with the aim of adapting the methodology to different data and environments. There is a special focus on developing countries where the majority of land desertification occurs.

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Monitoring trends in desertification: learning from ACRIS

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Abstract: Lessons learned from implementing the Australian Collaborative Rangelands Information System (ACRIS) could provide valuable insights into the effective functioning of a global dryland observation system (GDOS) to better monitor trends in land degradation and desertification. It is important that the potential collaboration and data contributions of partner countries are recognized within a widely agreed set of monitoring themes that enable the data to be collated up in scale effectively. Involving these countries in early-stage collation, analysis and synthesis of available data will (i) build commitment to a GDOS; (ii) better identify gaps in current data and knowledge that prevent objective monitoring of land degradation and desertification; and (iii) clarify member capacity to contribute to an effective GDOS.

Keywords: collaborative monitoring, coordination, multi-scaled, rangelands

Introduction

A global dryland observation system (GDOS) is proposed for collecting data about suitable indicators of land degradation and desertification. In particular, a GDOS would facilitate repeatable measurements for monitoring desertification that are harmonized across countries and scales. Coordinated data collation and analysis and subsequent reporting should provide stakeholders with more objective information for implementing appropriate policy and on-ground action to halt land degradation and combat desertification.

But what would a GDOS look like, and can it start to deliver useful information at an early stage? ACRIS, which has similarly coordinated degradation monitoring across disparate jurisdictions in Australia, could provide useful insights into the structure and operation of a GDOS.

Body of work

ACRIS is a coordinating partnership between federal and state governments with responsibility for managing natural resources in Australia's rangelands. It draws on monitoring data at various scales (regional to national), using local expertise to interpret local monitoring data into agreed common themes relevant to rangeland users, as well as national datasets which help contextualize the disparate sources of local data. The resulting analyses provide value both for national decision-makers investing in natural resource management, as well as providing benefits to state and local decision makers, who subsequently build their commitment to the process. These benefits come both from ready access to the broader national datasets (which might otherwise have been costly and duplicative for each state to develop) and by providing a framework for understanding and analysing change in relation to human impact that individual states have mostly lacked the capacity to develop.

ACRIS has recently reported change in Australia's rangelands over the last two decades (Bastin et al. 2008). Information was assembled and reported using a framework based on drivers of change, their impacts on natural resources as key ecosystem services across scales, and some socio-economic responses. The report demonstrates how, at the national scale, a coalition of willing parties can assemble, analyze and integrate various data to report change such that the synthesized information has more value than the sum of separate partner reports. Not surprisingly, deficiencies in existing data were identified (eg there is a critical need to implement long-term monitoring of biodiversity in Australia's rangelands) but the lessons from the reporting process itself are more important here. These include:

- It takes time for the partners to see the value in the process, and the initial activity requires some facilitation with funding to support engagement.
- The results from initial efforts must provide benefits to partners so that they continue with the collaboration.
- As trust in the process emerges, an improved structure for assembling and analyzing available data and interpreting the emergent results develops, and partners become more prepared to change their local monitoring to fit in with the general framework.
- It is important to get started: available data may at first seem disconnected and will lack complete geographic coverage. But by working together partners come to see tangible benefits from a first-pass collaborative approach.

Conclusions

The lessons from ACRIS could be scaled up from the country level (Australia) with its disparate states, to an international scale with its constituent nation states. GDOS should operate to provide global-scale data to contextualize national and local monitoring of desertification. It should also provide the necessary coordinating mechanism to allow countries and their agencies to contribute existing relevant information to a more immediate and improved understanding of the extent of land degradation and desertification. In time, GDOS will improve monitoring capacity by providing consistent data at multiple scales and by coordinating the improvement of national monitoring programs where required. However, both its effectiveness and impact could be more quickly realized if its implementation takes account of Australia's experience in implementing ACRIS.

Recommendations for decision-making

ACRIS collates and analyzes available, but often disparate, data to understand and report change in Australia's rangelands (81% of the continent). Its establishment and partner engagement processes could provide a valuable model for implementing a GDOS. A GDOS will have enhanced value for more objectively monitoring trends in land degradation and desertification if the potential data contributions of partner countries are recognized and an early goal is set to collate, analyze and report on these available data.

Acknowledgements

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Appraising and selecting sustainable land management solutions

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Abstract: Much research has focused on desertification and land degradation assessments without putting sufficient emphasis on prevention and mitigation strategies, although the concept of sustainable land management is increasingly being acknowledged. A variety of conservation measures have already been applied at the local level, but they are rarely adequately recognized, evaluated or shared, either by land users, technicians, researchers, or policy makers. The diffusion of successful traditional and innovative practices among land managers in comparable contexts is further hampered by insufficient collaboration between researchers and those responsible for local implementation. Our aim is to present a new methodology for appraising and selecting sustainable land management options in a participatory process. The methodology combines a collective learning and decision approach with the use of evaluated global best practices in a concise three step process: i) identifying land degradation and locally applied solutions in a stakeholder workshop; ii) assessing local solutions with a standardized evaluation tool; and (iii) jointly selecting promising strategies for implementation with the help of a decision support tool. The methodology is currently being implemented in the EU-funded DESIRE project, and preliminary results are presented.

Keywords: sustainable land management, stakeholder workshop, best practices, decision support

Introduction

Agricultural advisors in desertification-prone areas are often confronted with the need to find ways to improve land and water productivity in order to support land users in their local area. How and where can they find best practices or proven strategies? How can they appraise and select the options that they identify? Can this be done in collaboration with stakeholders, in order to enhance ownership, feasibility and applicability? These questions drove the development of the methodology presented here, which is being tested and refined within the EU-funded project DESIRE (www.desire-project.eu) in collaboration with WOCAT (www.wocat.net).

Body of work

The goal is to promote a methodology for participatory sustainable land management appraisal and selection. It guides users through a process, starting from collective learning on desertification problems and respective solutions (Part I), to the description and evaluation of identified local solutions (Part II), and finally to jointly selecting potential solutions for implementation with the help of a decision support tool (Part III).

An initial 3-day stakeholder workshop aims to identify land degradation prevention and mitigation strategies that have already been applied in the local context. It brings together a diverse range of actors who, traditionally, hardly work together to solve problems. In this way it combines scientific and local knowledge while simultaneously supporting a co-learning process. The identified alternative options, including current practices and new or non-local measures, require further assessment – which is the objective of Part II. Comprehensive questionnaires and a database system developed within the WOCAT program are used to evaluate the identified sustainable land management solutions. The WOCAT questionnaires document and evaluate technical measures, as well as implementation approaches. Going through this process elucidates reasons behind successful local experience and exchanges valuable knowledge among different stakeholders, various study sites and worldwide. It is also the foundation for the selection and negotiation process in Part III, which comprises a second stakeholder workshop to select promising sustainable land management strategies for implementation. The decision support methodology consists of three elements: first, the global WOCAT database to choose sustainable land management options; second, Decision Support System software to support a decision-making process based on multi-criteria evaluation and third, a participatory approach to guide workshop participants through the process, allowing them to deliberate and negotiate the best option(s) in a structured way.

Conclusions

Preliminary evidence from application within the DESIRE project suggests that the methodology has a great potential to engage stakeholders and integrate local and scientific knowledge in a structured process of identifying, testing and validating strategies for sustainable land management. At the same time it contributes to a global knowledge base, is flexible enough to be adapted to specific local or regional conditions and allows sharing of sustainable land management knowledge worldwide.

Recommendations for decision-making

Any process of sustainable land management implementation should be preceded by a fair and structured appraising and selection process, involving relevant stakeholders. The options to take into account for implementation need to be based on local knowledge and be adapted to the local bio-physical and socio-economic circumstances. Their effectiveness should be well assessed before recommendation or implementation.

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Monitoring and evaluation system of sustainable land management projects

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Abstract: The projects dealing with sustainable land management in Moldova were reviewed in light of the major aspects related to impact assessment, including monitoring and evaluation systems. A 'managing for impact' approach, and benefit–cost and social return of investment analyses were used to determine to what extent the projects have reached the expected results.

Keywords: monitoring, evaluation, managing for impact, sustainable land management

Introduction

Agriculture, together with the food industry, represents 32% the GDP and 65% of the general export volume of the Republic of Moldova. Over 40% of the country's population is engaged in agriculture. The main natural treasure of the country is the soil. Eroded soils cover a surface of 40% of agricultural land. Several projects related to sustainable land management were implemented in Moldova in order to develop the basis for sustainable development in rural areas. NGO BIOS assessed the impact of the projects implemented during the period of 2002–2008.

Body of work

The monitoring and evaluation systems of sustainable land management projects implemented in Moldova are based more on statistical and research data related to soil and water quality and less on participatory instruments such as community-based indicators, local people empowerment tools etc. The projects were able to ensure an appropriate level of detail, but the level of participation of farmers and communities in monitoring and evaluation should be further strengthened. One of the weaknesses in the projects was the absence of a comprehensive monitoring and evaluation framework to systematically report on program implementation. Some monitoring activities including annual reviews, and intermittent field monitoring visits were carried out, but there was no systematic results-based reporting mechanism in place.

Environmentally friendly practices demonstrated high efficiency. Benefit/cost ratio varies from 1.6 to 4.1, while the internal rate of return was 52–230%. The net present values are positive at 12% of the real discount rate. The shrub and tree planting program was a catalyst for extension of the tree planting practices on the degraded lands, as well as of forest regeneration.

The projects were able to create networks and forums of major stakeholders to continue the learning and knowledge generation processes for improving overall development effectiveness and innovation to find new solutions for sustainable land management. The projects have reached the expected results in pilot areas; however local and central public administrations, farmers, non-governmental organizations and other stakeholders should continue the implementation of initiated actions in order to disseminate them all over the country.

Conclusions

- Most people are aware of all key focus areas and projects have basic capacities for strategic guidance towards impact, ensuring effective operations, creating a learning environment and establishing a sound monitoring and evaluation system. However the participation of stakeholders in all stages of the project cycle is up to 4 levels of participation according to Pretty's typology of participation.

- Data collection methods adopted in sustainable land management projects include surveys, inspection/observations, interviews, as well as the national standards for data collection and processing of water and soil samples. Farmers and communities were less involved as equal partners in the monitoring and evaluation process, thus not all data received from them are reliable.
- The projects used various channels to reflect critically on the results/outcomes. However, the materials of researchers are too scientific and complicated for farmers.
- There were limited funds to develop the capacities of project stakeholders, especially farmers and communities, which could have supported the monitoring and evaluation functions.
- Due to sustainable land management projects, most of the economic, social and ecological indicators at the end of the projects were improved in pilot areas.

Recommendations for decision-making

- Participatory planning monitoring and evaluation should be the main approach in the development and implementation of sustainable land management programs and projects.
- The sound monitoring and evaluation system should be incorporated in similar project proposals, and adequate resources and time should be allocated.
- More attention and assistance should be provided for data collection at all levels. Project partners and beneficiaries should be given simple data collection templates.
- Documentation for lessons learned should be strengthened and communicated to all relevant stakeholders.
- Regular comprehensive reviews are needed to assure management for impact and improving all related critical factors.
- Institute a system to build the capacity of grassroots-level stakeholders.
- Substantially increase the level of participation and use participatory methods and techniques to empower the local people.
- Gender issues should be cross-cutting in similar projects.
- To diversify awareness building actions according to sources of information preferred by the population.
- To emphasize specific examples of advantages followed up by the adoption of sustainable land management promoted by the projects.

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Knowledge management of sustainable land management benefits through WOCAT

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Abstract: WOCAT has developed an internationally recognized, standardized methodology to document and evaluated relevant aspects of sustainable land management technologies and approaches, including spatial distribution, allowing the sharing of sustainable land management knowledge worldwide. Analyzing this knowledge supports the formulation of policy advice.

Keywords: sustainable land management, knowledge management, best practices, standardized methodology, combating land degradation

Introduction

There has been a strong focus on studying and documenting soil degradation in the past, but a comprehensive presentation of sustainable land management practices, and soil and water conservation in particular, has not been undertaken sufficiently. In fact, a wealth of sustainable land management knowledge and information exists, but the challenge is to collect this and make it available for exchange of know-how between land users and sustainable land management specialists – including technicians and agricultural advisors – and for advice to planners, coordinators and decision makers.

Body of work

Based on the fact that numerous examples of sustainable land management practices exist, WOCAT has developed questionnaires and a database system to document, evaluate and disseminate these local experiences globally. This evaluation process, which occurs in a team of experts together with land users, greatly enhances understanding of the reasons behind successful (or failed) local practices – whether introduced by projects, newly developed by innovators, or found in traditional systems – and how to share its success among various sites. The use of the WOCAT tools stimulates evaluation (including self-evaluation as well as learning from comparing experiences) within sustainable land management initiatives where all too often there is not only insufficient monitoring but also a lack of critical analysis. The WOCAT process is based on three pillars:

1. The questionnaire on sustainable land management *technologies* addresses the specifications of a technology, the natural and human environment where it is used, and an analysis of the benefits, advantages and disadvantages, economic impacts, acceptance and adoption of the technology.
2. Sustainable land management *approaches* are defined as the ways and means of support that help to introduce, implement, adapt and apply sustainable land management technologies on the ground.
3. The *mapping* methodology is scale-independent and evaluating the spatial distribution of degradation as well as conservation and its causes and impacts for a watershed, a district or a whole country. Resulting maps serve decision makers in planning investments in sustainable land management.

Analyzing the documented sustainable land management practices reveals denominators of success (and failure). An overarching lesson is that prevention or mitigation is generally more cost-effective than rehabilitation. In dry areas, investments in water harvesting and improved water use efficiency, combined with improved soil fertility management, should be emphasized to increase production, reduce the risk of crop failure, and lower the demand for irrigation water. Such measures need not be costly; a fairly simple measure like mulching has great benefits in terms of soil moisture and soil fertility improvement.

Conclusions

More sustainable land management can increase income, improve food security and sustain natural resource productivity at the local level. At global and national levels it can safeguard natural resources and ecosystem services, preserve cultural heritage, and contribute positively where water scarcity, land use conflicts, climate change and biodiversity conservation are concerned. Scattered knowledge about soil and water conservation needs to be identified, documented and assessed via a systematic review process that involves the joint efforts of land users, technical specialists and researchers. WOCAT tools can facilitate comprehensive data collection, knowledge management and dissemination.

Recommendations for decision-making

Investments in sustainable land management must be carefully assessed and planned on the basis of properly documented experiences and evaluated impacts and benefits: concerted efforts are needed and sufficient resources must be mobilized to tap the wealth of knowledge and learn from sustainable land management successes. Further research is needed to quantify and value ecological, social and economic impacts of sustainable land management, both on-site and off-site, and to develop methods for the valuation of ecosystem services.

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Ensuring impacts from sustainable land management – development of a global indicator system (KM: Land)

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Abstract: The Interagency Initiative KM: Land (Knowledge from the Land) in its first phase on Ensuring Impacts from Sustainable Land Management – Creation of a Global Indicator System is developing a system of core indicators for use at the project level across all projects in the GEF portfolio on sustainable land management. A hybrid sustainable land management framework has been instrumental in the formulation of four global-level indicators supporting resource allocation in the Focal Area (land cover, land productivity, water availability and rural poverty), and five core project-level indicators for demonstrating the impact generated by GEF-funded sustainable land management initiatives (land use, land productivity, total system carbon, water availability and human well-being). The introduction of a comprehensive system of core indicators to be used across all projects to capture the impact of the portfolio brings opportunities and will strengthen the identification of project and portfolio contributions to the achievement of global environmental benefits.

Keywords: sustainable land management, indicators, knowledge management, global environmental benefits

Introduction

During the first phase of the long-term program KM: Land, the GEF Medium Sized Project "Ensuring impacts from Sustainable Land Management – Development of a Global Indicator System" aimed at providing the scientific-technical basis for selecting indicators to record the performance, results and best practices of sustainable land management projects in the GEF Land Degradation Focal Area. The KM: Land initiative has three specific objectives: i) develop global- and project-level indicators which *inter alia* demonstrate global environmental benefits and related local livelihood benefits derived from actions on combating land degradation; ii) exchange and disseminate knowledge and practices generated through sustainable land management projects and programs through a 'Learning Network'; and iii) provide the means to measure results and performance of sustainable land management projects and programs through a coordinated and/or harmonized inter-agency monitoring and evaluation approach.

Body of work

KM: Land initially undertook the development of a conceptual framework that integrates the elements of the Millennium Ecosystem Assessment with the more traditional framework comprising drivers, pressure, state, impact and response. This hybrid sustainable land management framework provided the basis to formulate indicators at different scales. At the global level, a combination of five selected indicators has been identified by the project that will serve the purpose of prioritizing resource allocation in the GEF Land Degradation Focal Area – land cover, land productivity, total system carbon, water availability and rural poverty. The identified socio-economic and bio-physical global indicators are all measurable through available global databases and ongoing remote sensing and monitoring initiatives.

At the project level instead, indicators were selected to measure global environmental and livelihood benefits derived from GEF projects in the Land Degradation Focal Area. KM: Land has compiled the state-of-the-art knowledge on well-established scientific methodologies to measure these project-level indicators, including land use, land productivity, water availability and human well-being. The further refinement of measurement methodologies at the project level (including measurement methodologies and reporting procedures) and development of guidance materials for GEF project managers on how to report on these indicators is underway.

In order to strengthen knowledge management in the GEF Land Degradation Focal Area, KM: Land also works on establishing a Learning Network to facilitate the dissemination of lessons from GEF projects and enhance the exchange of information and ideas between sustainable land management professionals. The initial Learning Network will mainly comprise three different components, including a website, communities of practice and a virtual resources center. The website will serve as a common gateway to the virtual Resources Centre and Communities of Practice and as the primary communication tool for the KM: Land project. Embedded in the website, the communities of practice component will be a mechanism for exchange of information, lessons and experience among sustainable land management professionals with a common interest. An expandable virtual Resources Centre has been proposed for storing, accessing, managing and retrieving information, materials and other resources from GEF projects, such as publications, proceedings, training materials, events, contacts and reports. This will require a database to create storage space for materials and information and a database management system according to the search-functionality requirements in order to assure effective extraction and delivery of information. The synthesis of relevant, generic information generated by GEF projects should be given priority during the follow on phase of the project. The need for synthesized products has been identified as one of the key gaps to be addressed.

Conclusions

The KM: Land initiative has developed project-level indicators, intervention logics and a knowledge management strategy. A close link has been established between the KM: Land project and the ongoing strategic developments occurring at the GEF, and the remaining activities for implementation were identified to move forward with the task of developing methodologies and reporting procedures for project-level impact indicators (based on the selected five project-level indicators: land cover, land productivity, water availability, total system carbon and human well-being). Further, work is underway to develop a framework for the design of new projects in order to assist agency task managers to link intervention logics with project impacts and with the GEF tracking tool development. The emerging global sustainable land management impact monitoring and knowledge management system will not only provide important guidance to the future strategic development of the GEF Land Degradation, but is also expected to generate impacts beyond the direct GEF realm. Synergies exist with the efforts of the UNCCD to develop impact indicators and benchmarks as well as to establish improved knowledge management systems to better capture best practices generated by Member States. The major outputs of the project are: a report on the feasibility of a core set of project-level indicators for use across the GEF sustainable land management portfolio; an initial report on criteria for selecting indicators, measurement methodologies and reporting procedures; a report on a proposed strategy for an integrated project-level impact indicator system for the GEF Land Degradation Focal Area and a review of GEF project intervention logics and an approach to strengthening GEF sustainable land management project designs through impact pathways; and v) a concept note on knowledge management in the GEF Land Degradation Focal Area. The project is currently working for the establishment of the KM: Land Learning Network.

Lessons from the global biodiversity indicators process

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Abstract: An essential tool for reaching global targets in the context of a multilateral environmental agreement is a suite of reliably measured and persuasively communicated indicators of trends and progress. An upcoming workshop convened by UNEP-WCMC on behalf of the Secretariat of the Convention on Biological Diversity will bring together leading biodiversity indicator specialists to review the use and effectiveness of the 2010 biodiversity indicators, with a view to providing guidance for the development of a robust post-2010 indicators framework. The expert workshop outcomes will include lessons and recommendations on global biodiversity indicators – their sufficiency, scientific rigor, policy relevance and effective communication – that are likely to be of interest and value to UNCCD indicator initiatives.

Keywords: biodiversity, global indicators, lessons learned

Introduction

Within this first Scientific Conference of UNCCD, Working Group 1 will provide advice on desertification and land degradation indicators. Many process lessons for a new suite of global land indicators can be drawn from the experience of global biodiversity indicators. The Expert Workshop on the 2010 Biodiversity Indicators and Post-2010 Indicator Development was held in Reading, UK in early July 2009.

Body of work

The 2010 Biodiversity Indicators Partnership (2010 BIP), coordinated by UNEP-WCMC with support from the GEF and the EC is producing global-scale biodiversity indicators, many of which are also applicable at regional, national and sub-national scales. The CBD, at its sixth, seventh and eighth meetings of the Conference of the Parties (Decisions VI/26, VII/30 and VIII/15), adopted a framework of goals and targets for the 2010 Biodiversity Target of achieving, "by 2010, a significant reduction of the current rate of biodiversity loss at the global, regional and national level, as a contribution to poverty alleviation and to the benefit of all life on Earth". A range of indicators were agreed upon for measuring progress towards the target. In response, the 2010 Biodiversity Indicators Partnership was established. The 2010 Biodiversity Indicators Partnership aims to provide the best available information on biodiversity trends to the global community in order to assess progress towards the 2010 target. Discussions are currently also underway regarding the development of post-2010 global biodiversity targets and indicators.

Conclusions

Conclusions will be devised through a synthesis of the Reading workshop outcomes regarding:

- what level of detail is **sufficient** to provide useful information on achieving global goals and targets
- to what extent global indicators must be **scientifically rigorous**, logical and comprehensive in order to be useful in decision-making
- to what extent indicators are **policy-relevant** and taken up by the policy community
- how indicators are **communicated** effectively, both individually and in combination
- the different **needs and capacities** for development and application of indicators at the global, regional and national scales.

Recommendations for decision-making

Specific recommendations of use to decision makers at the COP will be developed in full after the Reading workshop outcomes are synthesized.

Resources

Background documents for the Reading workshop are available at: www.cbd.int/doc/?meeting=EMIND-02

The 2010 Biodiversity Indicators Partnership website has relevant technical reports on biodiversity indicators: www.twentyten.net

Social, economic and political dimensions of desertification, shared benefits of mitigation[1]

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Abstract: Compared to the significant shared benefits of investments in sustainable land management, the level achieved in the implementation of the UNCCD is still limited. In the present international framework, measures on DLDD are mostly integrated within agricultural investments, which have steadily shrunk over the last years. The UNCCD may contribute significantly to reaching development goals through increased awareness at high political level on the socio-economic and political dimensions of DLDD, policies conducive to sustainable agricultural production, enhanced investment in land-related measures, revival of the 'green revolution' in agriculture, scientific and technological development and transfer, and the use of 'climate change momentum' to encompass land-related measures among targeted mitigation measures.

Keywords: United Nations Convention to Combat Desertification, sustainable land management, socio-economic and political dimensions

Introduction

Although all three are outcomes of the UN Conference on Environment and Development (Rio de Janeiro 1992), the three Rio sister Conventions (on climate change, biodiversity and desertification) differ considerably in scope and in success of implementation. Characteristic of the UNCCD is the particular concern for the world's extended drylands, the social component determined by the direct perception of DLDD phenomena by affected communities, the structure on regional annexes, and also the limited degree of implementation. Given the shared benefits of sustainable land management measures for reaching development goals and environmental sustainability, the synergies between the three Rio environmental agreements may now be considered as important as the peculiarities.

Body of work

The immediate causes of desertification are: 1) unsecured property rights failing to create incentives for sustainable land management investments; 2) unwise practices of land use change and cultivation; 3) limited technological development and transfer; and 4) discrepancies regarding global trade barriers and land-related subsidies, which further reduce the resilience of drylands (GIZ, UNCCD 2008; WRI 2005). The major sources of funding for UNCCD are the budgets of affected countries, completed by overseas development assistance through bilateral agreements and international donors (IFAD, GEF, EU, World Bank). Besides the limited efficiency and fragmentation of overseas development assistance, it is generally acknowledged that investments in sustainable land management are well below what is necessary to address DLDD. While governments in many developing countries now invest less than 4% of gross domestic product in agriculture – although it remains a key economic sector – the figures on the amount of the "production sector" within the global overseas development assistance shows a decrease of commitments from \$5.22 billion from 1990 to 1994 (18% of the total overseas development assistance) to \$3.41 billion from 2000 to 2004 (7% of the total overseas development assistance) (IDA 2007).

[1] Paper based on the desk study conducted March–May 2009 within the BMZ, based on a fellowship granted by the Robert Bosch Foundation

Under these circumstances, it came as little surprise that the countries facing an acute food crisis in 2008 are those most affected by DLDD phenomena.

DLDD cannot be viewed in isolation from other environmental issues, such as climate change, based on the direct relationship between carbon sequestration and land fertility. The current mitigation potential of land-related measures in drylands is underutilized, for reasons such as the current format of carbon markets, difficulty in defining projects' additionality (ie value that they add over the current situation) and baselines, predominance of small-scale farms and high transaction costs (IFPRI 2008). As carbon sequestration is not expected to become a priority in drylands, land management options enhancing carbon sinks, soil fertility and environmental quality may be given higher consideration in the current development efforts (GIZ 2008).

However, while many of the benefits accruing from investments in sustainable land management measures are rewarded by existing markets, a good part of associated ecosystem services (eg freshwater supply, nutrient cycling, soil formation, climate regulation, landscape and recreation) fall within the public domain, so that their recompense requires appropriate policy instruments. Avoiding another case of market failure (similar to the current warming of the Earth's climate) should therefore represent a great concern for governments, even though the global benefits of investments in sustainable land management have not yet been thoroughly calculated. At the global level, it is estimated that the annual income foregone in areas immediately affected by desertification amounts to approximately $42 billion each year (GEF 2006).

Conclusions

Sustainable land management definitely pays off. The shared benefits of investments in sustainable land management are foremost food security, climate change mitigation, environmental quality, salvation of local economies, reversal of land degradation, and by doing so a great input to the far-reaching goals of security and prosperity. Reversing DLDD through sustainable land management will address the interrelated environmental issues more efficiently than by excluding land-related investments. A comprehensive study on the ecosystem services of sustainable land management and the costs of DLDD (similar to a 'Stern Report on desertification') is encouraged, but knowledge management has to be complemented by action.

Recommendations for decision-making

Capture the awareness on DLDD and sustainable land management of key actors at the highest political level.

- Promote the designation of institutions (eg property rights), policies (eg incentives and taxation) and markets conducive to sustainable production at realistic prices.
- Enhance investment in land-related policies and measures, by mainstreaming existing funding, assuring coherence among different financing mechanisms, and identifying additional funding from domestic sources, donors and the private sector.
- Revive the 'green revolution' that showed the benefits in the past, and integrate it within the sustainable development programs.
- Enlarge the domain of agricultural investments over drylands, as they offer enormous potential for carbon sequestration and biomass production, and concentrate on land cultivation techniques and projects, rather than land use change.
- Support research, technological transfer, monitoring and appropriate investments on economically efficient, socially acceptable environmentally friendly technologies.
- Take advantage of the climate change momentum and include land-related projects into the Kyoto Protocol's flexible mechanisms and the agreement on the post-2012 commitment period (eg forest and cropland management, biochar etc).

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Acronyms and abbreviations

ACRIS	Australian Collaborative Rangeland Information System
AIDCCD	Active exchange on indicators and development of perspectives in the context of the UNCCD
AU	animal units
AVHRR	Advanced Very High Resolution Radiometer
BIOTA AFRICA	BIOdiversity Monitoring Transect Analysis in Africa
BMZ	German Federal Ministry for Economic Cooperation and Development
CACILM	Central Asian Countries Initiative for Land Management
CBD	Convention on Biological Diversity
CENPAT	National Patagonian Centre
CERZOS	Centre for Renewable Natural Resources of the Semiarid Zone
CONICET	Consejo Nacional de Investigaciones Científicas y Técnicas
CST	Committee on Science and Technology
DDP	Dryland Development Paradigm
DIS-EISI	Desertification Information Systems – Environmental Information
DLDD	desertification, land degradation and drought
DNI	DesertNet International
DRC	Democratic Republic of Congo
DSD	Dryland Science Consortium
EC	European Commission
ECLAC	Economic Commission for Latin America and the Caribbean
Embrapa	Empresa Brasileira de Pesquisa Agropecuária / Brazilian Enterprise for Agricultural Research
EVR	Ewes' visibility range
FAO	Food and Agriculture Organization of the United Nations
GDOS	global dryland observation system
GEF	Global Environment Facility
GIS	geographic information system
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
ha	hectare
IADIZA	Argentine Institute for Research on Arid Lands
ICARDA	International Center for Agricultural Research in the Dry Areas
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IFAD	International Fund for Agricultural Development
IFEVA	Institute for Physiological and Ecological Research linked to Agriculture
IFFN	International Forest Fire News
IFPRI	International Food Policy Research Institute
INTA	National Institute of Agrarian Technology
IPCC	Intergovernmental Panel on Climate Change
JRC/IES	Joint Research Centre/Institute for Environment and Sustainability of the European Commission
KM: Land	Knowledge from the Land
LAC	Latin America and the Caribbean
LADA	Land Degradation Assessment in Drylands
LOR index	Lack Of Rain index
MARAS	Monitores Ambientales para Regiones Aridas y Semiáridas
MEDRAP	Northern Mediterranean Regional Action Programme
MODIS	Moderate Resolution Imaging Spectroradiometer
NDVI	Normalized Difference Vegetation Index
NEPAD	New Partnership for Africa's Development
NGO	non-governmental organization

NRD	Nucleo Ricerca Desertificazione
OECD	Organisation for Economic Co-operation and Development
OSS	Sahara and the Sahel Observatory
REDEN	Regional Desertification Network
SAyDS	Secretaría de Ambiente y Desarrollo Sustentable
SLM-IS	Sustainable Land Management Informational System
SWALIM	Somalia Water and Land Information Management
TPN	Thematic Programme Network
UBA	University of Buenos Aires
UN	United Nations
UNCCD	United Nations Convention to Combat Desertification
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UN-REDD	United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries
UNU-INWEH	United Nations University – Institute for Water, Environment and Health
VU	vegetation unit
WCMC	World Conservation Monitoring Centre
WFP	World Food Programme
WMO	World Meteorological Organization
WOCAT	World Overview of Conservation Approaches and Technologies programme
WRI	World Resource Institute
ZEF	Zentrum für Entwicklungsforschung / Center for Development Research, Germany

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Abstract
This Proceedings documents the deliberations of the First UNCCD (United Nations Convention to Combat Desertification) Scientific Conference on 'Understanding Desertification and Land Degradation Trends', held in Buenos Aires, Argentina, from 22 to 24 September 2009. It includes introductory and keynote presentations, summaries by Session Chairs, conference recommendations, and poster summaries. The Proceedings were edited by members of the Dryland Science for Development consortium, the body that organized the scientific format of the Conference.

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